THE USE OF CONCEPT MAPPING AS A STRATEGY FOR INSTRUCTIONAL DESIGN IN A UNIT FOR HIGH SCHOOL BIOLOGY

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ABSTRACT

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In this thesis, the emphasis was placed on an alternate instructional strategy called "concept mapping". An attempt was made to compare the effects of two instructional strategies which were a concept mapping approach and a traditional teaching practice for a biology unit in a Human Biology course. The interaction of students' ability in reading and the instructional treatment was also investigated. Secondary school biology students were first assessed for reading ability using the SDRT. All groups were required to write three tests: a pretest, a midsession test and a posttest. An affective questionnaire was also administered but only to the concept mapping group in order to solicit students' attitudes, beliefs and judgments about the concept mapping methodology. The first finding of the study was that reading ability interacts significantly with the acquisition of biology content. Increments in scores from the midtest session to the posttest session also indicated that high level concept mapping students performed much better than the same level students in the traditional group. Finally, an analysis of section 2 of the posttest, designed specifically to measure relation among concepts, illustrated that students of lower caliber performed significantly better on this section than their traditional counterparts, which helped to

partially confirm the main hypothesis. When carefully integrated into normal classroom procedure, concept mapping can function as an effective instructional tool.

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Chapter 1

Rationale

Historically, teachers have addressed each of their classes as a single group, and have rarely varied the assignments, the requirements, the tests, the instructional methods, or the grading system so that they correspond with what students are capable of producing. With the advent of technology, varieties of strategies were promoted to ensure that everyone learned. In public schools many programs were changed in order to adapt to the new technology but many of these did not succeed in making the best use of students' individual learning styles. Moreover, even though the concept of individual differences was well recognized and respected, this important principle of learning was not integrated into the day-to-day practice of subject matter teaching. This has been due to the fact that the teacher's task is simplified greatly when all members of the class are engaged in the same activity at the same time to achieve the same goal. The task became somewhat more complicated when individual differences demanded that even given a single universal goal for all students, different instructional strategies must be matched with different student capabilities. Hence, there has always been a divergence between educational research and educational practice. Some serious discrepancies have resulted in the field of instructional practice. Many methods have not facilitated learning and understanding of subject-matter in the classroom to the extent anticipated. Landa

(1976) has reminded us of this reality when he declared that "the discrepancy between what students are able to learn by attending school for a given period of time and what they should learn is continuously increasing" (p.29).

One discipline where this discrepancy has been obvious is the biology curriculum at the high school level. Biology is often a difficult subject for many people. Because they were unsuccessful in understanding high school biology, adults often know little about their bodies or their environment. High school students [illegible]ently have a hard time understanding the content of biology because of its highly conceptual nature.

<u>A new perspective in biology and science education.</u> One of the probable reasons why the teaching of biology has encountered problems was that it has been too zealous in producing a better curriculum. It has concentrated so much in presenting the subject in more efficient and agreable ways that it has largely ignored the far more basic question of "how to facilitate learning". The implication here, is that there has been a tendency over the years to consider more seriously the problem of how one teaches biology than the problem of how students learn biology. In other words the field of learning research has not been able to provide methods that can adequately facilitate the learning of subject content in the classroom. Since biology and science education as a whole stood in need of a new focus, that focus could have been on how to make biology and science easier to understand. Hertig (1976) and Yager (1981) have advocated

that there can and should be more serious investigations by teachers into the problem of how students learn the discipline.

Douglas (1979) has developed a means of teaching biology so that information would be mentally more palatable for students if it were presented in a form they were best able to process. She investigated the interrelationship between the ability to think analytically and the sequencing of teaching materials, but her study also included the application of an individualized learning strategy. The results of her study supported the hypothesis that students are more academically successful in learning biology when the instructional materials they use complement their style of thinking.

Matching cognitive styles to individualized instruction. The recent surge of interest in cognitive styles originated from a concern for individual differences. Over the last decade, research on cognitive styles has been the object of methodological refinement and empirical substantiation. Messick (1970) for example, listed and described nine separate cognitive dimensions that have been the object of systematic, theoretical and empirical examination.

Cognitive style has been defined as individual variations in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information (Kogan, 1971). Douglas (1979) in her study, recommended that individualized instruction should employ teaching materials to complement each student's method of thinking. She studied the effects of two teaching strategies on two different types of thinkers, analytical vs non-analytical or global thinkers. Highly analytical students did better with inductive strategies and highly global students did better with deductive materials.

Although the study by Douglas (1979) was valid within a research context the following query nevertheless is raised: how valid can a study be when its recommendations can hardly be implemented, especially in the domain of public education? The fact is, that in most public schools, it is still virtually impossible for a teacher to rigorously apply a type of scheduling congruent with that of individualized instruction. Cost is another constraint that cannot be ignored. We can be almost certain that whatever teaching strategies we use at whatever cost, students will never react ideally (Joyce, 1980).

Biology inquiry - oriented instruction: theory or practice? The teaching of biology has often been viewed as a method of learning based on inquiry or discovery. Egan and Greeno (1970) interpreted learning by discovery as being a method by which students proceed by solving problems and generalizing with very little initial information. Formal thought is usually required for successful inquiry because the student must hypothesize abstract concepts to successfully reach a solution. However, it was soon made apparent by the above authors that early adolescent students found learning by inquiry more difficult than traditional rote learning.

Even though many biology programs have purported the use of the inquiry approach, recent studies of secondary school science instruction have shown that few teachers actually used inquiry-based approaches in their classrooms. Surveys of selected American schools have demonstrated that 70% of the students said that less than 25% of teacher time was spent in inquiry teaching (Stake & Easley, 1978). The reasons given were that the necessary equipment and supplies were hard to provide, and students had difficulty in carrying out inquiries effectively. Furthermore, most teachers still continued to use the textbook as their principal source of instructional activity because students have had tremendous difficulty in understanding "what was going on". Consequently, students responded by rote learning few definitions of terms, and by seeking attention through various forms of disruptive behavior.

Main objective of this thesis. Very little has been done to stress the facilitation and understanding of concepts and information in biology. There has been a steep failure rate on ministry examinations for the past number of years (Dufour, 1981), suggesting that the traditional manipulation of the subject matter has proven ineffective. The emphasis in this thesis was expressly placed on an alternate strategy called concept mapping. The concept mapping approach had its origin with Ausubelian learning theory. Concept maps are diagrams indicating relationships between concepts, but more specifically, they can be seen as hierarchical diagrams drawn along vertical and/or horizontal dimensions and that attempt to reflect the conceptual organization of a discipline or a segment of a discipline.

It was the purpose of the study to show that some of the theoretical ideas cited by Ausubel could be applied to school science learning, more specifically to biology learning. The literature has revealed that concept mapping has been mainly applied in the college and university setting, and where it has proven quite successful (Bogden, Note 1; Moreira, 1979). But empirical evidence from the primary and secondary school setting is negligible. The aim of this study was to apply the concept mapping strategy in the biology classroom, and compare its effects to the traditional manipulation of the instructional materials.

This approach of facilitating and improving learning finds theoretical support in the work of David Ausubel. Ausubel's (1968) assimilation theory has guided much of the research on curriculum development but has been especially useful in developing the concept mapping approach to instruction. The key principle in Ausubel's theory is that any new learning is highly dependent on the adequacy of relevant concepts. These concepts derive increasing meaning as they become integrated into a progressively more complex conceptual framework. Gowin (Note 2) defined concept mapping as a technique of analysis where one can show on paper a conceptual structure, which is a cluster of concepts and the way in which they are related. Moreira (1979), Stewart, Van Kirk and Rowell (1979) are other researchers who have investigated concept mapping and its potential role in teaching. Novak (1979, 1980a, 1980b, 1981) has especially commended its use. Concept maps in several senses of the word are flexible tools. How they are used and what concepts and relationships are included are matters left to the users, within the constraints imposed by the structure of biology. The degree of focus can vary considerably, but maps can act to: (1) identify major conceptual areas to be covered in the biology unit; and (2) describe how major conceptual areas interrelate to provide overall coherence.

In that biology requires the understanding of a multitude of new concepts and the relationship among them, the most essential learning ability seemed to be reading. The teacher cannot necessarily assume that all students can read sufficiently well that they would be able to create concept maps. Furthermore, reading ability is a valid and reliable indicator of a student's overall academic performance. A student's size of vocabulary and level of reading skills and abilities are important factors affecting his/her attitude towards subject matter. An individual with inadequate reading skills is much more discouraged by the inability to comprehend meaning and reject tasks than one with high level skills (Russel, 1970). In view of the fact that reading ability is both easy to assess, and is a potent indicator of success, it was seen as a valid variable in examining its interaction with the instructional treatment. Since students with low reading ability encounter the most difficulty with the conceptual content, it was therefore contended that the concept mapping strategy might prove to facilitate their learning more than the highly capable, given that they could construct or use concept maps.

Also within the context of reading ability, science textbooks are often not suitable for students because they do not match their reading level. Using an instrument provided by Kenedy (1979) and developed by Fry (1968), the study determined the reading level of the biology textbooks used by the students. This was done to insure that there would be no serious discrepancy between the books' approximate reading level and the students' grade level.

Summary. This thesis attempted to integrate two main areas of inquiry which seem to be rationally related. Ausubelian theory has provided a good theoretical rationale for using concept mapping in its effort to increase the efficiency of information-processing capacities to meaningfully absorb and relate bodies of knowledge. Since reading ability is also an important factor in learning, an interaction in the students' reading ability and the instructional treatment was also anticipated. It was expected that there would be an interaction between reading ability and instructional treatment, with low reading ability students benefiting greatly from the concept mapping treatment and high ability students performing equally well under both treatments.

In trying to focus upon the learner rather than the materials to be learned, this study has subscribed to the definition of educational technology which emphasizes the diagnosis of educational needs, the design of effective learning systems, and the assessment of achievement through educational measurement and evaluation. In implementing the concept mapping strategy, the study has attempted to satisfy the need of teaching biology so that information is more easily processed. By working in close collaboration with the respective teacher, this study also fulfilled the task of designing an entire instructional package, where instructional objectives were identified; instructional materials and activities were set up and implemented. Finally, through the application of several tests including an affective questionnaire, the study has also been able to monitor the progress of students, to form some useful judgments about the characteristics and achievement of students and especially assess the efficacy of the instructional strategies.

Chapter 2

Review of the Literature

The major components investigated in this study are the concept mapping instructional treatment and reading ability. These have not been integrated elsewhere within the confines of any empirical inquiry. Concept mapping has roots which are well anchored in a specific learning theory. When viewed as a tool in facilitating the teaching and learning of concepts and propositions, the framework described by Ausubel (1968) seemed most appropriate. Ausubel's model is aimed specifically at the learning which takes place in schools and has assisted considerably in building a theoretical basis for learning in school settings. Since concepts play an important role in school learning and in the mastery of subject matter, special attention is given to the discussion of "concepts", and their function in concept mapping and basic information-processing. It was also within the scope of this study to examine the effects of reading ability on achievement.

Ausubel's assimilation theory

Much research has been done dealing with learning theory and the nature of knowledge production. Researchers such as Pavlov, Ebbinghaus, and Skinner have all exercised some measure of control and had very little direct relationship to ordinary classroom learning. In a recent study of behavior in primates, Terrace, Petitto, and Sanders (1979) have found that there is only a narrow margin of similarity between human concept formation and animal learning even with learning by apes or chimpanzees. Though human language uses many levels of structure, the sentence represents a main aspect of communication. The sentence subsumes the work whose meaning is only arbitrary. Unlike words, most sentences cannot be learned individually. Psychologists, psycholinguists, and linguists are in general agreement that using a human language indicates knowledge of a grammar. How else can one account for a child's ultimate ability to create an indeterminate number of meaningful sentences from a finite number of words? These considerations have led Terrace et al. to conclude that "an ape's language learning is severely restricted because they can learn many isolated symbols (as can dogs, horses, and other non-human species) but they can show no unequivocal evidence of mastering the conversational, semantic, or syntactic organization of language" (p.901). In any case, there is general agreement today that human concept learning is central to rational thought.

David Ausubel (1963, 1968, 1978) has provided perhaps the most useful paradigm for the type of learning going on in schools, especially to the type of learning involved in science education. A full discussion of the relevance of Ausubel's theory to education is available elsewhere (Novak, 1977), but particular to this thesis, his assimilation theory has been especially useful in the development of the concept mapping approach to instruction. Concept mapping seemed to be a useful strategy for demonstrating how some key concepts in this theory can work. The key concepts of assimilation theory are subsumption, progressive differentiation, superordinate learning, and integrative reconciliation. These need to be briefly considered because they have helped to promote the use of concept maps in instruction.

Student-constructed concept maps have shown that they can encourage new learning which involves subsumption because students constantly use new propositions to elaborate and refine concepts they already know or are familiar with. Consequently, concept maps can help those concepts to derive increasing meaning as they become integrated into a progressively more complex conceptual framework. Novak (1980a) has illustrated this with the use of the concept of a 'plant'. He showed that "the concept plant facilitates a wide range of new learning when it includes relationships to the meaning of photosynthesis, evolution and development" (p.60). Thus a progressive differentiation in the meaning of the word 'plant' results over time from an ontogenic point of view.

Concept maps can also show new relationships between two or more familiar concepts as students learn new and more inclusive "higher order" concepts. Novak (1980b) pointed out that "when a biology student learns that fish, reptiles, whales, dogs, and humans are all chordates, some new superordinate learning is occuring" (p.284). Finally, the last key concept which is probably always occuring to some degree with subsumption or superordinate learning, is integrative reconciliation. Concept maps can accomodate integrative reconciliation when students recognize that their maps have two different concept labels which have essentially the same meaning, whereas before they were seen as unrelated. Novak (1980b) demonstrated integrative reconciliation using the chordate example again. He pointed out that "students probably begin to understand that all vertebrates are chordates, but not all chordates are vertebrates. The students' concepts of vertebrates, fish, shark, animal, and chordates are integrated into a somewhat altered meaning structure. The students' cognitive maps so to speak, have some new connections and maybe have dropped off some less precise old connections" (p.284). All of the above concepts in assimilation theory can facilitate meaningful learning. But this learning is dependent upon the idiosyncratic concepts individuals hold. These are derived from the current concepts held in society, impinging on the individual.

Another key idea in Ausubel's theory has been his "advance organizers", and the role they play in facilitating meaningful learning as well. Advance organizers have been succinctly defined by LeFrançois (1979) as concepts or ideas that are given to the learner prior to the material actually to be learned. According to Novak (1980b), they are a kind of cognitive bridge; they serve to link some relevant concept or proposition in the learner's cognitive structure to the new concepts or propositions one wishes to teach. The pedagogic value of advance organizers obviously depends in part upon how well organized the learning material itself is. Though it is usually up to the teacher to determine what example, analogy, metaphor, model, a capsule of knowledge will serve as an advance organizer, students, not knowingly, are using them as well in the process of constructing concept maps. Since the first step in concept map construction is to list concepts or ideas from a given paragraph or unit, students are in effect getting a general overview of the key concepts they have to subsequently learn. Simultaneously, these students are providing themselves with an opportunity in later recalling information that may be relevant to the understanding of a future lesson or unit. Again, concept mapping can show, how another key idea in Ausubel's assimilation theory may be elucidated in terms of actual instructional practice.

Once more, the most important single idea in Ausubel's theory is meaningful learning. Meaningful learning occurs when new knowledge is consciously linked by the learner to existing concepts or propositions the learner already knows. Novak (1980b), elaborated further on this idea, and he proposed that "in order to achieve learning, three conditions must be present: (1) the new material must be inherently meaningful; we cannot meaningfully learn randomly scrambled textual material; (2) the learner must have a meaningful learning set, that is, s/he must actively try to link new knowledge with existing relevant knowledge; (3) the learner must possess relevant concepts" (p.282). In view of the above considerations, it follows that the challenge of the instructional designer is to select examples or activities that will allow learners to assimilate new concepts (or new elaboration) to be learned into the idiosyncratic conceptual framework they already have.

Reception learning as a theory for school learning and instruction. The verbal expository method has been used in schools many years before Ausubel's (1963) meaningful learning scheme. Even presently it is still the chief mode by which information is communicated. Although educational research has been exhaustive in producing models of teaching, the reception learning paradigm has been able to withstand the test of time. Reception learning has been defined by Novak (1979) as that form of learning where the regularities to be learned and their concept labels are presented explicitly to the learner, and needless to say, a very large proportion of school learning is basically of this sort. In contrast, discovery learning in its pure form, requires that the regularities in objects and/or events are first discovered by the learner, abstracted from the general context in which they occur, and perhaps given a concept label, although the latter is not part of discovery learning per se. In actual practice, discovery learning occurs primarily with very young children in the process of concept formation. This type of learning has been congruent with those who have investigated the growth of conceptual abilities as a function of age (Bruner, 1966; Inhelder & Piaget, 1964) and who have consequently stimulated a great deal of thinking around methods of discovery learning. As Novak (1979) recalled, concept formation occurs when for example, children discover that all things with four legs, a tail, and a bark are called dogs by older persons. Most discovery learning in schools is actually various levels of guided discovery learning, and a continuum from a pure reception mode of learning to a pure discovery mode of learning is observable. Since learners have different abilities in assimilating new knowledge into cognitive structures, it has been shown by Ausubel (1968, 1978) that this kind of continuum engenders another kind of continuum which ranges from almost pure rote learning to highly meaningful learning.

Consequently the implication has been that learning should be less rote and more meaningful, and that instruction should be planned in such a way as to change arbitrary, verbatim information to a type of information which can be consciously linked to existing, specifically, relevant concepts and propositions in cognitive structures. Some of these key elements have influenced recent research in science education, and have especially aided the development of concept mapping. If one accepts these elements in relation to learning, the importance of concepts and their relationships to each other in teaching and learning become obvious.

<u>Concept maps.</u> The concept map has been described by Stewart et al. (1979) as a device for representing the conceptual structure of a discipline or a segment of a discipline, in two dimensions. The linear, one-dimensional organization outline was a traditional way of representing information about a subject. Because of its added relational dimension, however, the concept map has been much more suitable for representing the propositional relationships among concepts. Without being overly simple, concept maps can be thought as being like roadmaps on which cities (concepts) are linked by

major highways (propositions). The basic unit of the concept map is therefore the "concept".

Despite much usage of the term concept in educational writings, a standard definition of "concept" as reported by Markle & Tieman (1970) is that it is a class or category all the members of which share a particular combination of critical properties not shared by another class. A more convenient operational definition provided by Gowin (Note 2) is that a concept is a sign or symbol that refers to regularities in events and in records-of-events. If concepts are thought of as words, words become records of concepts, and therefore concepts become the facts of language. Words are vehicles for concepts, which in turn becomes the medium of exchange in free communication. This view on the meaning of concept strongly concurs with Gordon Pask's (Note 3) formulation of stable concepts within his Conversation Theory. Pask characterizes the notion of a stable concept as being a cluster of wholly or partly coherent language processes, undergoing execution in the processing medium, and is organizationally closed insofar as the procedures are themselves reproducible from other concepts by operators. The basic belief in Pask's rhetoric is that concepts are also the units of conversation and dialogue, and paradigmatically, the language dialogue is 'concept sharing' between people.

While Pask and Gowin seem to have a common point of agreement with regard to the role of concepts in human conversation, there is however a divergence in their viewpoints. Pask regards a concept as a skill. He is not committed to whether it is executed in an internal medium, like the brain as an "intellectual behaviour" or partly in an "external medium" involving, for example, motor vehicles or rulers, pencils and paper. According to Pask, a concept is a plain skill, but he does not exclude the possibility of it being an intellectual skill. Gowin considers concepts more than just mental activities in the mind or physical entities of some sort in the brain. He deems that they are more like fluid events rather than fixed entities. Words are the records of concepts, but words are also the facts of language. Essentially, he therefore finds that facts require three related things: the event which happens, the record or the set of records of the event, and the judgment that the record is indeed the record of the event. Thus these three characteristics are necessary to the proper meaning of fact. Gowin emphasizes that when concepts or facts are exchanged in conversation, nothing is lost and much is gained. If one person gives an idea to someone else and s/he gets one in return, no one then loses their original idea and both gain each other's.

It follows from these preceding propositions that if instruction is to be considered as a remarkably efficient process, it should first be able to attain the criterion of an exchange of factual information. In order to achieve this, students should be exposed to methods or strategies that can greatly improve their ability to master this information. Hence, the information processing capability of students and their individual differences should also be considered.

Concept mapping - an alternative strategy to increase information-processing. Since the concept mapping approach has been considerably influenced by Ausubel's assimilation theory, it can best fit into the family of 'information-processing' models. Even though it is basically a teaching model, concept mapping was primarily designed to increase the efficiency of information-processing capacities to meaningfully absorb and relate bodies of knowledge. According to Joyce (1980) information-processing models "share an orientation toward the information-processing capability of students and ways they can improve their ability to master information. They refer to the ways people handle stimuli from the environment, organize data, sense problems, generate concepts and solutions to problems, and employ verbal and non verbal symbols" (p.16). Although concept mapping does not claim to do all these things, it does maintain that it can stimulate intellectual functioning with students' individual differences in mind.

Information-processing has three distinct but related levels within the human system (Novak 1980b). These are sensory, short-term and long-term levels. Sensory information is acquired by our eyes, ears, and other sense organs; it is then transmitted to our information store. Sensory information is retained briefly, perhaps for periods of one second or less. Short-term memory retains information for periods ranging from one second to thirty seconds, longer if constantly rehearsed. It is the system that helps to construct meanings and manipulate images or symbols. Short-term memory is also known to hold information long enough in order to be evaluated and interpreted. The storehouse of knowledge we carry with us is our long-term memory. This knowledge is used in daily tasks of all kinds, and assists in the interpretation and subsequent storage process.

Fundamentally, memory has been defined as the retention of learning (Hebb, 1966). As such, Hebb (1966) has emphasized that "it must be a lasting modification of transmission paths, something which concerns the relation between neurons" (p.122). Therefore, it follows that newly acquired learning must be left undisturbed for sometime if it is to last. This process, in physiological terms, has been called 'consolidation'. It seems that in the case of long-term memory, consolidation has to last long enough in order to make learning more meaningful. It has been shown by Novak (1980b) that short-term memory is only a pathway by which knowledge input reaches long-term memory centers. And the transfer of information from short-term centers to long-term centers occurs along a two-way path. In contrast to the limited capacity of short-term memory, long-term memory has an almost unlimited capacity provided it is used effectively. It is mainly through their methodologies that educators can help students absorb new knowledge into their long-term memory in such a way that most new learning is facilitated. As mentioned earlier, concept mapping can represent an effective methodology in allowing the transfer of information from the students' immediate memory to their long-term memories and vice-versa. Though individuals possess different periods of consolidation it can still hopefully enhance their ability to process information according to their own cognitive structures. It was therefore reasonable to view concept mapping as a remedial instructional method that could be beneficial to all, but especially productive with students of low ability.

Educational research on concept mapping. Research on the concept mapping approach has been rather confined. Only two studies were available for review, Moreira (1979) and Bogden (Note 1). Moreira (1979) illustrated the use of concept maps in the teaching of electromagnetism. In his study, the independent variables seemed to be the two approaches to the content of an introductory course in electromagnetism for science and engineering students. One was based on the learning theory of Ausubel, and the other on the traditional content organization found in most textbooks on the subject. Concept maps were used in both approaches, and the dependent variable was the results on specific tests which he designed to measure differences in students' ability to relate and to differentiate electromagnetic concepts. One of these tests was a 'concept mapping' test which he administered at the beginning, at the middle and at the end of the course. Although the aim of this experiment was not to show the advantages of either approach and their influence on concept maps, it seemed that those maps constructed under the Ausubelian approach showed better conceptual relationships. In another study, Bogden systematically used concept maps in a college-level genetics course. He constructed maps with proportionally large instructional components to correspond to the content of individual lectures in the course, and then used them as a focus for discussion sections. Later on, he also used a genetics concept map to structure an integrative final examination for the genetics course.

It is highly questionable whether these two studies qualify as real studies. It seems from the onset, that, they both defy the essence of true educational research. Though the intent may have been respectable, both studies seem to be just personal undertakings with no real concern for the prospective scientific reader. Moreira's study (1979), for example, was not an experimental design and thus failed to provide the proper controls. Bogden's treatise, on the other hand, was not an empirical study at all. It was simply a well-organized instructional design package using concept mapping as the chief methodology used in the intended genetics course. The main point of both articles was only to show concept mapping as a potentially useful tool in the teaching of physics and genetics. These references were notdeemed to be highly suitable in the production of the present thesis, but they represent the only available and related articles to the study at hand.

Neither of the above studies examined the effect of a specific aptitude variable with the concept mapping treatment. This may have been due to the fact that ATI research has been "awfully unconvincing" (Glass, 1970). ATI research is still too important to reject on such narrow grounds. This study has therefore sought to establish the relationship between reading ability, a significant classroom variable, and concept mapping.

Reading ability. Reading ability seemed to be a useful variable because it is a good indicator and perhaps one determinant, of a student's academic achievement. It is a verbal skill that plays a substantial role in much of school learning. Most academic subject matter involves the mastery of abstract verbal concepts acquired through reading. The function that this ability has in the logical organization and the meaningful structure of educational content need not be emphasized. It was hypothesized then, that the incorporation of this variable within the parameters of the study should help in making better predictions of learning in the classroom. Consequently, the aim of this thesis was to regard reading ability as an intellectual skill central to achievement. According to Gagné & Briggs (1974), intellectual skills are "the capabilities that the human individual is competent in. They enable him to respond to the conceptualization of his environment. They are the most basic, and at the same time, the most pervasive, structure of formal education" (p.23). Since one of concept mapping's basic tasks involves the reading of subject matter content before actually mapping out relational concepts, reading ability seemed to be an ability which was highly compatible in a possible interaction with the main experimental treatment. In school, low readers are usually confronted with more difficulty when faced with conceptually laden subject matter. Hence the concept mapping technique was hoped would be relatively more effective for this level of students. The concept map would help compensate for their relative inability to manipulate verbal labels and relations, assuming they construct an adequate map.

The major sections of this thesis have been mainly devoted to the description of the concept mapping approach and its relation to learning theory. The analysis of the reading ability was considered in light of its likely effects on concept development using concept mapping as an instructional technique. The conviction that concept mapping can be a valuable tool in curriculum instruction, and perhaps in evaluation, has stemmed from the preliminary research of a few studies only, but as mentioned, empirical validity was scanty. This thesis has therefore accepted the challenge to pursue further investigation in the domain, in order to add more evidence to the precept that there is a definite link between learning theory and teaching.

Chapter 3

Method

Design

This study compared two instructional strategies, a traditional teaching practice and a concept mapping approach for teaching a biology unit in a Human Biology high school course. The instructional strategies consisted either of a traditional teaching approach whereby the teaching style was primarily teacher-oriented and where the teacher used the lecturing method in sequencing the instructional activities from available books and materials, or, of a concept mapping approach which mainly stressed propositional relationships among concepts using the same books and materials. The second independent variable, reading ability was measured by the Stanford Diagnostic Test: Blue Level (SDRT) (1974). Reading ability was included to see if the reading level of the students would influence the relationship between instructional strategies. Three levels of reading ability were differentiated by the subjects' scores on the SDRT. A third variable was also examined. All groups were required to write three tests: a pretest, a midsession test, and a posttest. These three positions were designed to assess the possible differential effects of concept mapping development with reading ability over time.

The design consequently followed a mixed-group design format (see Figure 1). In this format, two variables were independent and fixed, and one more factor was repeated. The three independent variables

FIGURE 1

Experimental Design

INSTRUCTIONAL STRATEGY

READING ABILITY	traditional	concept mapping
high	TEST INTERVAL* pretest midsession test posttest	same
medium	same	same
low	same	same

* The pretest, the midsession test and the posttest represents the repeated independent variable.

were the strategies and the reading ability of the students, and the repeated variable was the test interval.

Subjects

The sample was made up of secondary 4 and 5 students of both sexes, and who had chosen Biology 412 as an optional course at Lester B. Pearson Comprehensive High School. Most of these students came from similar socio-cultural backgrounds. This school serves a community which is essentially made up of first and second generation immigrants. The sample of subjects originated mainly from a population of Italian ethnic backbround. The first language at home was probably different from the one used in the school, which was a further reason for the inclusion of the reading ability component.

Materials

One test was used to rank the students on their reading ability. The SDRT, Blue Level, is able to measure phonetic and structural analysis, reading vocabulary, literal and inferential comprehension, reading rate, scanning and skimming of the students in grades 9 through 12. Since the purpose of this study was not really to assess the students' ability to scan and skim to increase reading efficiency, the author did not include subtests 6 and 7 of the SDRT. Hence only subtests 1 through 5 were administered.

Two instructional strategies were used. The first, as mentioned earlier, was a traditional approach to teaching biological science. In this fashion, the normal classroom teacher covered the content of a customary unit in the Biology 412 curriculum entitled, "The

Nervous System". The teacher sequenced the learning of this unit by following the main outline of the program prepared by the Ministry of Education of the Province of Quebec (MEQ). The main method was lecturing using teacher and professionally prepared materials. This included the use of the overhead projector, slide projector and film strip projector. The unit was complemented by having the students do a few standard practical laboratory exercises. This strategy as well as the second strategy was print-based. It derived its content chiefly from two main sources: Modern Biology by Otto and Towle (1973), and Human Physiology by Morrison, Cornett, Tether and Gratz (1977). Both these texts have readability levels that fall within grades 9 through 12 according to Fry's (1968) formula for estimating levels of reading.

The second strategy made use of the same printed materials as the first. The main difference was that instead of following the basic methodology exposed above, the instructor followed an approach which based itself on a more 'meaningful' learning strategy. This approach stressed the crucial role that concepts play in guiding the production of new knowledge and in meaningful (as distinct from rote) learning. The students in the experimental group were shown by the instructor howto construct propositional charts and concept maps from the main texts. They were expected to construct their own maps soon after. The unit was complemented with some laboratory exercises in this group also.

The pretest, the midsession test, and the posttest consisted of questions selected from a pool of numerous objective questions from past provincial examinations, questions prepared by the authors of the textbooks mentioned above, and by teacher-prepared questions. These tests were administered before commencing the unit, during the unit, and after the unit was terminated. Section 2 of the final posttest had a special function in the process of assessing the achievement of those students involved with the concept mapping strategy. This section was designed in order to evaluate the students' abilities in learning relationships among concepts (see Appendix C).

During the last session before the beginning of the next unit, an affective questionnaire was also administered but only to the concept mapping group (see Appendix D). The questionnaire was composed of 12 statements and 2 open-ended questions, all formulated to solicit students' attitude, beliefs, and judgments about the concept mapping methodology. All responses were quantified along a Likert scale, except for the last two.

Procedure

The SDRT was administered during two sittings in the first week of October for the 1981-82 school year in both groups of subjects. The raw scores from these tests were converted into average percent scores which were then ranked in order to isolate three reading abilities high, medium, and low. The two classes were composed of students who had registered in Biology 412 from the previous school year. The requirements were that they had to obtain a 60% passing grade in English and that they were not failing more than two other subjects. Administrative constraints prompted these groups to be intact. Each of the two groups was nevertheless randomly assigned to the experimental or control condition. As mentioned earlier, the experimental group received the concept mapping instructional treatment, and the control group received a traditional type of instruction by the same teacher. The unit taught was the Nervous System which involved the structures and functions of the nerve cell, the nerve impulse, the central nervous system, and the human senses.

The experimental group's instructor was given careful training regarding the implementation of the concept mapping procedure. He read studies by Gowin and Novak in preparation, and integrated the technique into his normal classroom procedure. He began the unit with a discussion of the meaning of 'concepts' and concept maps. Five class periods were used to teach simple construction of concept maps from the content in the main textbooks. During this time, students were also given time to practice their own map construction, so that they acquired experience in effective reading. Some of these maps were used as a basis for discussion in order to emphasize the meaning of concepts. Finally, during the remainder of the class sessions, students were also asked to produce four more concept maps dealing with the following concepts: (1) the spinal cord; (2) the reflex arc; (3) the external ear; and (4) the middle ear (see Appendix F). These particular concept maps were collected and then graded on a five point comprehensive scheme developed by Novak (1981). Students were told that these maps were important, and they represented a fraction of the term's grade.

A pretest was administered in both groups during the class period before the actual unit began under the guise of general information gathering for the course. A midsession test was also given. This time each group was told that this test would be assessed in partial fulfillment of the term's grade. Students were forewarned at least one week in advance. The students wrote the final posttest during the fourth week after the initial pretest. Finally, during the very last class before the next unit commenced, the affective questionnaire was administered but only to those students in the experimental group.

It is important to note that both groups covered the same material over the same period of time. The time spent by the experimental group learning how to generate concepts maps was not additional, but included in the fixed sequence of sessions.

Chapter 4

Results

The pretest, midsession test and posttest were constructed so as to measure equivalent concepts throughout the session. The tests were therefore considered to be more or less the same with many items being simply paraphrases of one another, while others were new, but assessing the same knowledge content. Nevertheless, to insure that violations of repeated measures analyses were not left unaddressed, first conducted was a multiple analysis of variance using the three tests as dependent variables. Then analyzed were gain scores using ANOVA, assuming test equivalence, to see if different groups performed differently over time, expecially with respect to the treatment. Finally, an ANOVA on section 2 of the posttest was completed separately because it was specifically designed to measure students' abilities to deal with conceptual relationships.

Individual differences. Reading levels were first determined by administering subtests 1 through 5 of the SDRT to all subjects. From these 5 scores, average percent scores were ranked from top to bottom, and groups formed into reading ability levels. The average ranges of scores for each group were: 68-99 (high), 50-67 (medium), and 0-49 (low).

Main Experiment

MANOVA. The tests for homogeneity of variance on the three dependent measures were observed, with only the pretest in violation. A t-test was therefore completed to ascertain the equivalence of the treatment groups, resulting in $t(42) = .86$. The groups were thus equivalent, and no further analyses were conducted using the pretest. Means and standard for all tests, levels, and treatments are listed in Table 1.

The only significant effect yielded in the MANOVA was for level of reading, the overall $F(6,68) = 5.54$, $p < .001$ (Hotellings). Both univariates were significant for the midsession and posttests, $F(2,37) = 14.29$, $p < .001$, and $F(2,37) = 11.09$, $p < .001$, respectively.

The post hoc analysis using Scheffé's multiple comparison procedure revealed that marked significant differences existed within the reading levels. On the midsession test, all reading group comparisons were statistically different. High-low, high-medium and medium-low comparisons were $F(1,41) = 29.1$, $p < .001$, $F(1,41) = 5,28$, $p < .05$ and $F(1,41) = 12.11$, $p < .01$ respectively. Finally, on the posttest only, high-low and high-medium group comparisons were statistically significant, $F(1,41) = 22.07$, $p < .001$ and $F(1,41) = 9.89$, $p < .005$.

<u>Gain scores (midsession test to posttest).</u> The increments in scores from the midtest session to the posttest session produced an interaction between treatment and reading ability. A two-way ANOVA for the interaction involving the treatment and reading ability showed that there was a statistically significant effect, $F(2,37) =$

Table 1

Means and Standard Deviations on the three Tests for

All Levels of Reading Across both

Experimental (Concept Mapping) and Control (Traditional) Groups

GROUP		READING LEVEL HIGH	MEDIUM	LOW
EXPERIMENTAL	n =	6	10	8
PRETEST	$\bar{X}$ =	40.00	27.00	27.50
	SD =	21.90	12.29	7.07
MID-SESSION TEST	$\bar{X}$ =	60.33	50.20	37.13
	SD =	22.20	9.86	16.37
POSTTEST	$\bar{X}$ =	75.50	60.70	50.00
	SD =	15.72	16.28	14.81
CONTROL	n =	8	7	4
PRETEST	$\bar{X}$ =	43.75	25.00	31.25
	SD =	15.29	6.45	10.30
MID-SESSION TEST	$\bar{X}$ =	71.38	42.71	29.00
	SD =	13.46	18.05	11.46
POSTTEST	$\bar{X}$ =	71.75	54.14	44.50
	SD =	14.78	11.17	5.74

3.24, $p < .05$. Table 2 shows the means and standard deviations of the gain scores for both groups. Figure 1 graphically represents the reading level X treatment interaction.

Additional analyses using Tukey's test revealed that there were three specific interactions between ability groups. The first interaction which is clearly shown by Figure 1 demonstrates that the concept mapping treatment favoured the high level students much more than the same level students in the traditional treatment group. There was a statistically significant difference of $F(1,12) = 3.96$, $p < .05$. Another test also revealed that there was a marginally significant difference between low level students involved in the concept mapping treatment, and the high level students subjected to the traditional treatment, $F(1,14) = 3.50$, $p < .06$. Finally, only one significant difference resulted from comparisons within separate treatment groups. The significant interaction was between the low level students and the high level students of the non-treatment group, $F(1,10) = 3.59$, $p < .05$.

Posttest scores (section 2). Section 2 of the posttest was especially designed to measure the relational structures of concepts in conformity with the concept mapping methodology. A two-way ANOVA on section 2 of the posttest showed that there existed a marginally significant interaction between teaching method and reading ability, $F(2,37) = 3.04$, $p < .06$. The means and standard deviations of this particular analysis are presented in Table 3. Figure 2 illustrates

Table 2

Means and Standard Deviations of the Percent Gain Scores from the Midsession Test to the Posttest for both Experimental (Concept Mapping) and Control (Traditional) Groups

GROUP			READING LEVEL HIGH	MEDIUM	LOW
EXPERIMENTAL	n	=	6	10	8
% GAIN SCORES	$\bar{X}$	=	15.17	10.50	12.88
	SD	=	9.50	9.03	6.67
CONTROL	n	=	8	7	4
% GAIN SCORES	$\bar{X}$	=	.13	11.43	15.50
	SD	=	7.53	14.47	12.67

FIGURE 1

Interaction between Reading Levels and Instructional Treatment using Gain Scores from the Midsession test to the Posttest

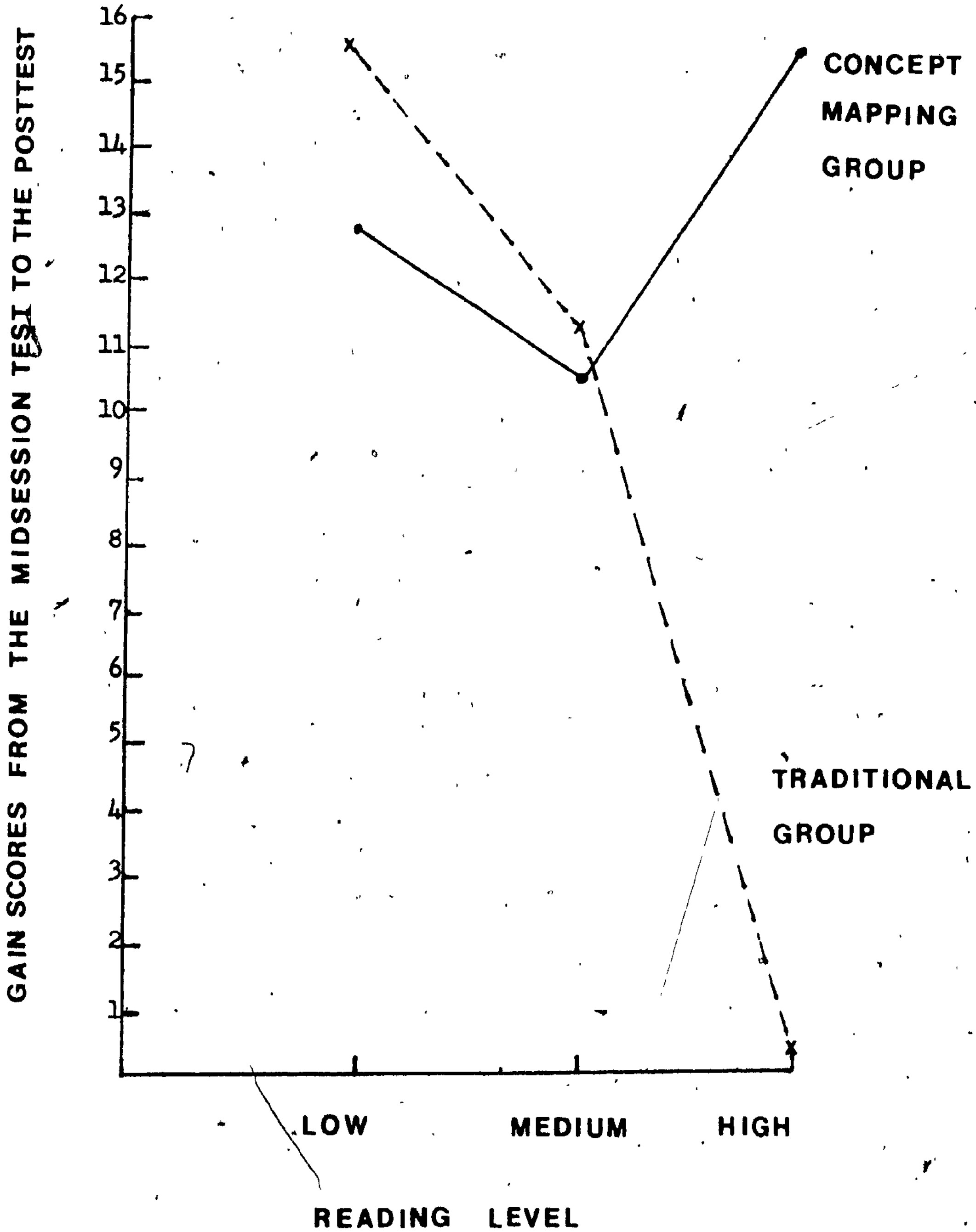


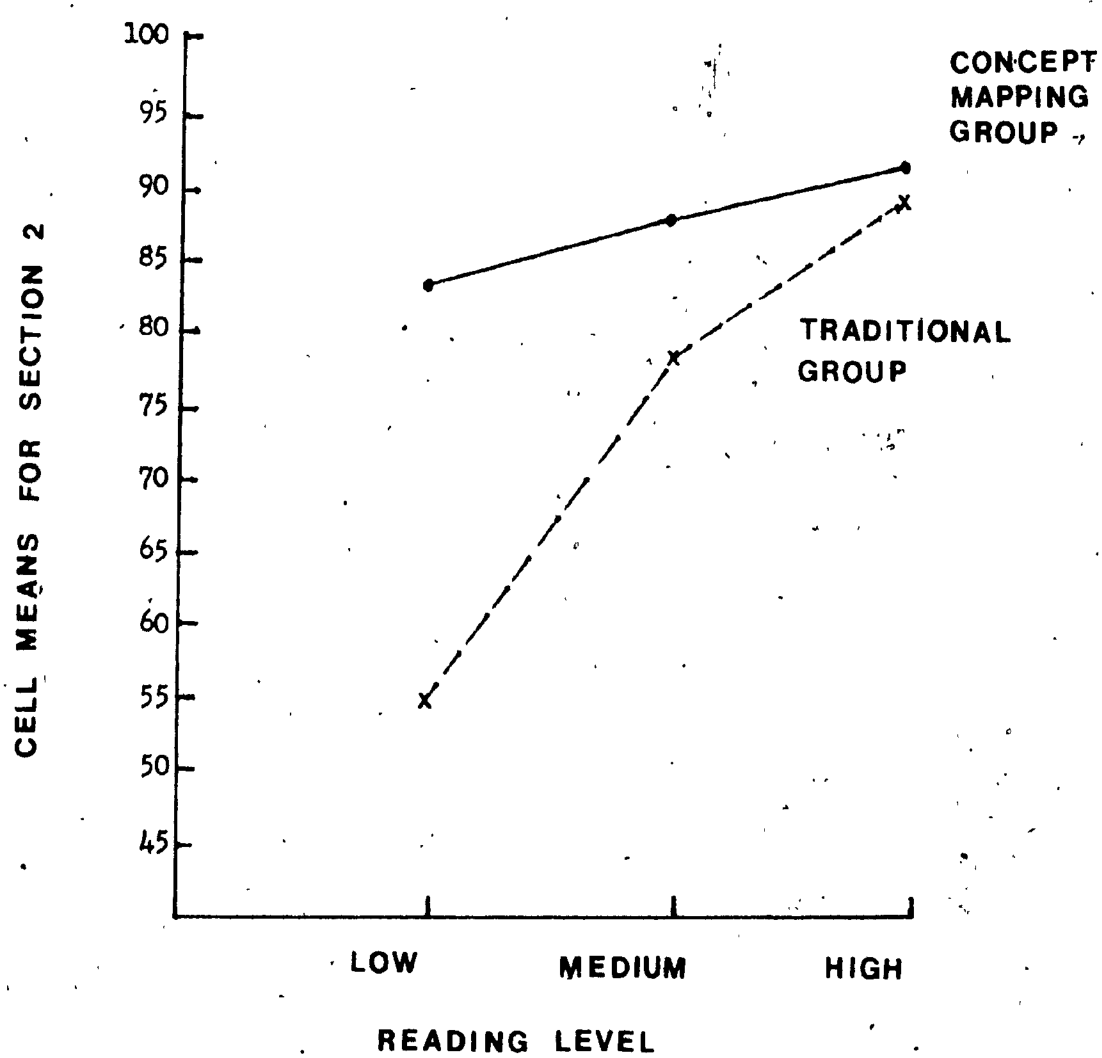
Table 3

Means and Standard Deviations of Section 2 of the Posttest Scores for both Experimental (Concept Mapping) and Control (Traditional) Groups

		READING LEVEL		
GROUP		HIGH	MEDIUM	LOW
EXPERIMENTAL	n =	6	10	8
SECTION 2 SCORES	$\overline{X}$ =	93.33	86.00	82.50
	SD =	10.33	13.50	12.81
CONTROL	n =	8	7	4
SECTION 2 SCORES	$\overline{X}$ =	91.25	78.57	55.00
	SD =	12.46	12.15	19.15

FIGURE 2

Interaction between Reading Levels and Instructional Treatments for Section 2 of the Posttest ($p < .06$)



the interaction.

A simple multiple comparison of means indicated that the low level students in the concept mapping group performed significantly better on section 2 of the posttest than those students in the traditional group, $F(5,37) = 11.67$, $p < .01$. The students with high and medium ability showed no difference.

<u>Affective data.</u> The responses on the affective questionnaire were converted and ranked along a scale of 1 to 5. These were then tallied according to reading level. The means for each question were also calculated (see Appendix E). The results indicated that high level students preferred concept mapping to other teaching methods. The answers on the two open-ended questions showed that most of these students also expressed a general satisfaction for the method in its ability to facilitate the taking of notes from their textbooks.

Chapter 5

Discussion

The main goal of this study was to make a genuine attempt in prescribing and applying an instructional strategy that would satisfy a real educational need. Based on a limited body of research, concept mapping was believed to be one viable alternative in facilitating the learning of information in an instructional unit in biology. It was first hypothesized that students with weaker reading skills would have benefited more from concept mapping than students with stronger skills in reading. The traditional treatment of the unit was thought to be less effective with students of weaker ability. Furthermore, it was also assumed that students with a higher reading level would have shown no marked increase in performance in spite of the instructional treatment. The rationale was that high ability students are usually in need of little structure and are able to process information efficiently, no matter what the instructional method. These hypotheses were partially supported.

The first effect considered was that of the instructional program's overall effectiveness. The results have shown that the only significant effect was for the level of reading. Even though the means have shown that subjects improved their performance over time, the concept mapping was not found to be significantly better than the traditional treatment. A closer analysis of the multiple comparison tests revealed that different rates of acquisition existed for learners of different reading ability. High reading ability students achieved significantly better increments on both the midsession and posttests. Low reading ability students on the other hand performed least well on these tests. These relative differences among reading ability groups remained throughout the instructional session. This may have seemed to be inconsequential at first, but in view of the fact that there were definite time constraints on the study, the concept mapping strategy could perhaps have provided better results for the slower learners if the teacher had been able to spend more time training the students in the construction of concept maps.

As mentioned earlier in the study, reading ability was not a randomly selected variable chosen to correlate with the performance of individuals, nor was it meant to be any characteristic that could have limited the generality and the inferential value of the present study. Reading ability was chosen to promote the concept that it interacts with the specific instructional strategies (Hunt, 1975). The results have shown that there were basically two main interactions between reading ability and the concept mapping strategy.

One interesting and unexpected result was the interaction involving the midtest to posttest gain scores and reading ability. The gain scores reflected how much additional information each group acquired from one test to the next. Surprisingly, in this analysis, there were no overall differences among reading ability groups.

However, while both low and medium readers performed similarly under both the traditional and concept mapping approaches, the high readers performed very differently under the two treatments. In spite of the fact that analogous gains were also expected in both treatment groups, the high level group which received the concept mapping treatment obtained significantly better gain scores.

A closer look at the mean scores indicated that the experimental treatment was successful in bringing high learners from an already high score level to a better score level. The traditional instruction on the other hand, was not able to enhance mean scores beyond the second test session. In addition, all mean scores also revealed the experimental treatment's advantage in maintaining a straight progression of scores in all reading levels across the three test sessions.

There was yet another result from this gain score interaction. Unexpectedly the traditional group yielded increments that were inversely related to reading ability. At first glance, this data appeared contradictory. On the average, low and medium ability groups gained more than high ability students. However, when separate instructional treatment were considered, the high ability group performed extremely well with the concept mapping treatment but made no gains in the traditional group.

On the basis of the foregoing, the evidence then appeared to be supportive of the earlier proposition in the thesis which stated that information-processing must have played a vital role in the interaction between the instructional treatment and reading ability. Consequently, the concept mapping approach must have had a greater impact on the cognitive styles of the students. The extent of this impact was difficult to predict but it was clear from the midtest to posttest gain scores, that concept mapping seemed to favour high ability students more than the traditional approach.

In view of the fact that reading ability and cognitive style are closely related intellectual skills (Gagné & Briggs,1974), it was inferred that the information-processing capability of the concept mapping approach capitalized more strongly on cognitive strengths than the traditional treatment. Therefore high ability students in the experimental group were probably more able to match their conceptual levels to the type of instruction they received. They were thus able to obtain better increments beyond the midtest. The students who received the traditional treatment may not have received the necessary amount of structure to match their own conceptual levels or learning styles (Hunt, 1971). This may have also explained why these students did not achieve higher scores past the midtest session. Added to this interpretation is the position set forth in Bovy's (1981) locus of information-processing approach. In this approach, it is presumed that the actual stages of information-processing during instruction and learning vary considerably with learning task and learner. However, it is also reasonably assumed that the success or failure of individual learners depends to a large extent on whether they can successfully apply previously acquired cognitive skills to solve specific learning tasks. The author therefore reasons that if a learner both possesses a particular processing skill, and can correctly apply it to the appropriate problem, no external instructional method would be required. According to this scheme, the locus of information is "inside" or controlled by the learner, and no instructional method is required. In relation to the above interaction however, it seemed that the concept mapping treatment was necessary. Consequently the concept mapping instruction provided greater maximal cognitive processing support. Probably the high learners profited more from concept mapping than from the traditional treatment because it may have directed cognitive processing in an optimal manner (Rigney, 1978).

Affective data from the questionnaire administered only to the experimental students added further support to the above interpretation. It seemed from the analysis of these data that the concept mapping approach, in a positive way, influenced the achievement motivation of the high reading ability students. These students expressed more concern and had a more positive attitude towards concept mapping than those in the medium and low reading groups. The changes in grades from the midtest to posttest could also have been influenced by the need for motivation. Since concept mapping is a method that provides students with room for creativity, it was inferred that the motivating power associated with it influenced the increment in grades. This finding was consistent with previous research on motivation where teaching methods facilitated the performance and the learning of specific tasks (Day & Berlyne, 1970; Torrance, 1971).

The other important interaction that helped in partially confirming the prediction that low and medium ability students would have benefited more from concept mapping than the traditional approach, involved section 2 of the final posttest. This section of the posttest was expressly designed to measure what Gowin (Note 2) termed the "conceptual structure" or the "simple constructs" of basic information on the unit on the 'Nervous System'. Concept mapping brought about the desired effect on the achievement outcome of the low reading ability students as predicted. The low ability students in the traditional instructional group obtained significantly lower scores on this section. Although the medium and high ability groups using concept mapping also performed better than their traditional counterparts, these differences were not statistically significant.

A closer examination of these results further showed that the concept mapping technique helped low readers most on specific tasks in overcoming their cognitive weaknesses. It did not improve their overall performance, however. This "failure" to improve overall performance can be seen as much a function of the actual test as "achievement". If tests measure memorization, rote learning techniques prove most effective, especially over a short term. If an understanding of relationships is called for, concept mapping appears to be beneficial.

These results also seemed to be in agreement with the basic matching principle, "low conceptual level learners profit more from high structure, and high conceptual level learners profit more from low structure" (Hunt, 1971). The idiosyncratic nature of the concept mapping approach was not as advantageous for the low ability students in coping with the material because it didn't give them the structure they required. The concept mapping technique did not provide the general didactic guidance that this type of student needed, but only facilitated a particular form of learning. This interpretation is again in agreement with Bovy's (1981) locus of information-processing scheme. Since low learners have fewer idiosyncratic cognitive skills, or are unable to apply them, the main instructional strategy was not able to generally facilitate cognitive processing.

As a final consideration, reading aptitude was examined in terms of its actual usefulness in predicting student performance. The results have unequivocally indicated that reading ability does indicate how well an individual will perform relative to another, even though all groups improved over time. It became apparent that reading ability can be a useful instructional factor within the confines of the experimental design.

These above findings made possible two tentative inferences, partially hypothesized and partially unexpected. First, the concept mapping strategy can be designed to benefit low reading ability students if the method is used selectively and discrimantly in the instructional sense. Second, concept mapping can strengthen the high reading ability students' skills in conceptualizing and remembering information.

This research lends further support to the contention that no matter what teaching strategy one uses, all students cannot be led to the same point of mastery (Joyce, 1980; Joyce & Weil, 1972). The spectrum of reading abilities and learning styles in the classroom will always make it difficult for a researcher to assign subjects to differential educational treatments at any given time and expect these methods to have generalized effects. Nevertheless, despite the incessant constraints due to individual variation, the concept mapping approach did seem to be a practical strategy in helping to curtail some of the gap between the instructional process and the educational goals of the individual students. Even though the study was exploratory, it still represented a well-grounded attempt in seeking basic facts. The results have attested to the existence of some significant relationships between learner characteristics and instructional method. More importantly, this study has also found that the type of information being taught and tested influences the appropriateness and efficacy of a given instructional technique. Concept mapping cannot intuitively replace all other methodologies either within biology or across other topics, but it can provide a realistic alternative approach provided it is used selectively with students and teaching materials in mind.

Recommendations. Merrill (1971) has advocated that the process of instructional design can be conducted in at least two ways. One procedure can be characterized as the "raw empiricism" approach, whereby a designer proceeds in his investigation without any attempt to apply any theoretical system systematically. A second procedure consists of the "paradigm" or "model building" approach. It is on the latter approach that this study has modelled itself. A sensible attempt was made to develop instructional theory through the experimental investigation of the paradigm called "concept mapping". This study has also ascribed to the definition of instructional technology which provides direction in the systematic planning for establishing a way to examine the instructional problem and need of students, for setting an instructional strategy in solving the problem, and for assessing the results (Kemp, 1977).

In conclusion, this thesis would recommend that concept mapping be not considered as a methodology that can be applied to an entire curriculum, even like biology, or that it can be used for any type of student. It should be regarded as a technique tobe used very carefully only where it will emphasize those mental processes than can be used by the learner. It should be used where it will teach a deeper understanding of concepts and their specific relations, but not in the general memorization of facts. Consequently, major considerations should involve adequate teacher and student preparation with the technique. As the results have shown, practice is of the upmost concern, and enough time should be spent on the construction of maps. Testing methods should also be further investigated that would be more congruent with the type of instruction and the type of skills characterizing the students.

This study only represented a cursory look into the concept mapping approach. More concept mapping as well as other techniques should perhaps be developed and tested to add empirical validity in linking learning theory to teaching. Biology was only one general discipline; other disciplines should also be investigated, and other abilities should be searched out for other possible valid interactions.

Reference Notes

Reference Notes

1. Bogden, C.A. The use of concept mapping as a possible strategy for instructional design and evaluation in college genetics. Unpublished thesis, Cornell University, 1977.

2. Gowin, D.B. Educating. Unpublished manuscript, Cornell University, 1979.

3. Pask, G. Concepts, coherence and language. Paper presented for the Netherlands Institute for Advanced Study, The Netherlands, April 1980.

References

References

Ausubel, D.P. Educational psychology: A cognitive view. New York: Holt, Rinehart and Winston, 1968.

Ausubel, D.P. The psychology of meaningful verbal learning. New York: Grune and Stratton, 1963.

Ausubel, D.P., Novak, J.D. & Hanesian, H. Educational psychology: A cognitive view. 2nd ed. New York: Holt, Rinehart and Winston, 1978.

Bovy, R.C. Successful instructional methods: A cognitive information processing approach. Educational Communication and Technology Journal, 1981, 29 (4), 203-217.

Bruner, J. The process of education. Cambridge, Mass.: Harvard University Press, 1966.

Day, H.I. & Berlyne, D.E. Intrinsic Motivation. In G.S. Lesser (Ed.), Psychology and Educational Practice. London: Scott, Foresman and Company, 1971.

Douglas, C.B. Making biology easier to understand. The American Biology Teacher, 1979, 41, 5, 277-298.

Dufour, M. Scholastic achievement: one of the ministere's concerns. MEQNEWS, January, 1981, pp. 11-13.

Egan, D.E. & Greeno, J.H. Acquiring cognitive structure by discovery and rule learning. The university of Michigan, 1970 (Ann Arbor ERIC. Document Reproduction Service No. ED062-667).

Fry, E. A readability formula that saves time. Journal of Reading, 1968, 11, 513.

Gagné, R.M. & Briggs, L.J. Principles of instructional design. New York: Holt, Rinehart and Winston Inc., 1974.

Glass, G.V. Aptitude - Treatment Interaction. In Wittrock, M.C. & Wiley, D.A. (Eds), The evaluation of instruction: Issues and problems. New York: Holt, Rinehart and Winston, 1970.

Hebb, D. A Textbook of Psychology. London: W.B. Saunders Company, 1966.

Hertig, W.H. A new focus in biology education. The American Biology Teacher, 1976, 38, 9, 543.

Hunt, D.E. Matching models in education: The coordination of teaching methods with student characteristics. Toronto: Ontario Institute for Studies in Education, 1971.

Hunt, D.E. Person – Environment Interaction: A challenge found wasting before it was tried. Review of Educational Research, 1975, 45, 2, 209 – 230.

Inhelder, B. & Piaget, J. The early growth of logic in the child. New York: Harper & Row, 1964.

Joyce, B.R. & Weil, M. Models of teaching. Englewood Cliffs, N.J.: Prentice Hall, 1972.

Joyce, B.R. Learning how to learn. Theory into Practice, 1980, 1, 15-26.

Kemp, J.E. Instructional Design: A Plan for Unit and Course development. California: Flaron – Pitmans Inc., 1977

Kenedy, K. Determining the reading level of biology textbooks. The American Biology Teacher, 1979, 41, 5, 301-303.

Kogan, N. Educational implications of cognitive styles. In G.S. Lesser (Ed.), Psychology and Educational Practice. London: Scott, Foresman and Company, 1971.

Landa, L.N. Instructional regulation and control: Cybernetics, Algorithmization and heuristics in education. Englewood Cliffs, New Jersey: Educational Technology Publications, 1976.

Le François, G.R. Psychology for Teaching. California: Wadsworth Publishing Co., 1979.

Markle, S.M. & Tieman, P.W. Conceptual learning and Instructional Design. In M.D. Merrill (Ed.). Instructional Design: Readings. Englewood Cliffs, New Jersey: Prentice - Hall Inc., 1971.

Merrill, M.D. (Ed.) Instructional Design: Readings. Englewood Cliffs, New Jersey: Prentice - Hall Inc., 1971.

Messick, S. The criterion problem in the evaluation of instruction: Assessing possible, not just intended outcomes. In Wittrock, M.C., & Wiley, D.E. (Eds.), The evaluation of instruction: Issues and problems. New York: Holt, Rinehart and Winston, 1970.

Moreira, M.A. Concept maps as tools for teaching. Journal of College Teaching, 1979, 8, 5, 283 - 286.

Morrison, J.F., Cornett, F.D., Tether J.E. & Gratz, P. Human Physiology. New York: Holt, Rinehart and Winston Inc., 1977.

Novak, J.D. A theory of Education. Ithaca, New York: Cornell University Press, 1977.

Novak, J.D. Applying psychology and philosophy to the improvement of laboratory teaching. The American Biology Teacher, 1979, 41, 8, 466-470.

Novak, J.D. Progress in application of learning theory. Theory in Practice, 1980, 19, 1, 58-65. (a)

Novak, J.D. Learning theory applied to the biology classroom. The American Biology Teacher, 1980, 42, 5, 280 - 285. (b)

Novak, J.D. Applying learning psychology and philosophy of science to biology teaching. The American Biology Teacher, 1981, 43, 1, 12-20.

Otto, J.H. & Towle, A. Modern Biology. New York: Holt, Rinehart and Winston Inc., 1973.

Rigney, J.W. Learning Strategies: A theoretical perspective. In H.F. O'Neil, Jr. (Ed.), Learning strategies, New York: Academic Press, 1978.

Russel, D.H. The Dynamics of reading. Massachusetts, Toronto: Ginn and Company, 1970.

Stake, R.E. & Easley, J.A. Case studies in science education. (2 vols), Washington, D.C.: U.S. Government Printing Office, (ERIC NO. ED166058, ED166059).

Stanford Diagnostic Reading Test. New York: Harcourt, Brace, Jovanovich Inc., 1977.

Stewart, J. Van Kirk, J. & Rowell, R. Concept maps: A tool for use in biology teaching. The American Biology Teacher, 1979, 41, 3, 171-175.

Terrace, H.S., Pettito, L.A., Sanders, R.J. & Bever, T.G. Can an ape create a sentence? Science, 1979, 206, 891-902.

Torrance, P.E. Creativity in the educational process. In G.S. Lesser (Ed.), Psychology and Educational Practice. London: Scott, Foresman and Company, 1971.

Yager, R. Science education, ASCD Curriculum Update, September 1981, pp. 1-6.

Appendices

Appendix A

PRETEST

<u>Select the choice that best completes each of the following statements.</u>

<u>Write your answers on the answer sheet provided.</u>

1. A synapse is:

   (a) the junction between the axon of one neuron and the dendrite or cell body of the next neuron.
   (b) the junction between cranial and spinal nerves.
   (c) a message which travels along a neuron.
   (d) the junction between the axons of two different neurons.
   (e) a nerve of the internal organs.

2. The outer layer of the human brain contains:

   (a) about 4 million cells.
   (b) about 14 billion cells.
   (c) about 12 million cells.
   (d) about 1 million cells.
   (e) less than 100 000 cells.

3. Receptors are:

   (a) centers in the brain that receive nerve impulses.
   (b) specialized nervous tissue sensitive to changes in our surroundings.
   (c) nerve centers in the spinal cord.
   (d) membranes on the surface of the spinal cord.
   (e) reflexes with which one is born.

4. Nerve fibers conducting impulses away from the central nervous system are:

   (a) efferent fibers.
   (b) receptor fibers.
   (c) afferent fibers.
   (d) association fibers.
   (e) none of these.

5. Conduction in nerves depends on:

(a) movement of electrons as when current passes through a wire.
(b) an electro-chemical process which is self-propagating.
(c) an entirely chemical process.
(d) the reflex arc.
(e) involuntary functions.

6. The dura mater is:

(a) a thin delicate covering of the surface of the brain.
(b) a tough protective covering lining the vertebral canal and skull.
(c) a membrane containing the blood vessels that nourish the spinal cord and brain.
(d) a mixed nerve.
(e) all of these.

7. The anterior roots of the spinal cord:

(a) bring efferent fibers away from the cord.
(b) bring motor fibers to the cord.
(c) bring afferent fibers to the cord.
(d) are used in diagnosing certain infections.
(e) are openings at the base of the skull.

8. Blushing is controlled by the:

(a) brain.
(b) autonomic nervous system.
(c) central nervous system.
(d) automatic nervous system.
(e) peripheral nervous system.

9. A simple reflex arc represents:

(a) a learned response.
(b) an unlearned response.
(c) a partially learned response.
(d) a branching, treelike nerve process that carries impulses toward the cell bodies.
(e) the brain regions that controls the activities of the internal organs.

10. The cerebellum is concerned with:

(a) balance, coordination of motion and muscle tone.
(b) coordination of impulses between the cortex of the brain and the inner portion of the brain.
(c) sleep and emotion.
(d) vision.
(e) the sympathetic nervous system alone.

11. The sensory area of the brain is located in:

(a) the frontal lobe.
(b) the parietal lobe.
(c) the occipital lobe.
(d) the temporal lobe.
(e) none of these.

12. The autonomic nervous system is responsible for:

(a) involuntary control of our internal environment.
(b) voluntary control of respiration.
(c) coordination of muscular activity.
(d) almost no activity in the body.
(e) the wrinkles of the cerebral cortex.

13. Color vision is due to the activity of:

(a) the rods.
(b) the cones.
(c) the rods and the cones.
(d) the cornea.
(e) the aqueous humour.

14. The image projected on the retina of the eye is:

(a) upright.
(b) inverted and reversed.
(c) upright and reversed.
(d) usually blurred.
(e) none of the above.

15. The Eustachian tube:

(a) drains fluid from the middle ear into the mouth.
(b) keeps up pressure in the inner ear.
(c) keeps the pressure equal on both sides of the eardrum.
(d) is responsible for transmitting sound waves to the inner ear.
(e) none of the above.

16. The semicircular canals are associated with:

(a) hearing.
(b) balance.
(c) draining fluid from the middle ear.
(d) the sense of touch.
(e) the sense of vision.

17. Olfactory nerves are associated with:

(a) taste.
(b) hearing.
(c) smelling.
(d) sight.
(e) touch.

18. The terminal branches of the dendrites of sensory nerves in the skin are called:

(a) neurons.
(b) receptors.
(c) effectors.
(d) cranial nerves.
(e) impulses.

19. Which of the following is a chemical sense?

(a) taste.
(b) hearing.
(c) sight.
(d) touch.
(e) all of these.

20. If an injury to the spinal cord results in damage to most of the spinal nerves in the lower back, the symptom would be:

(a) total paralysis below the injury.
(b) paralysis of the legs only.
(c) loss of sensation in the legs.
(d) death of the tissues above the injury.
(e) death.

PRETEST

ANSWER SHEET

BIOLOGY 412

NAME: ________________________

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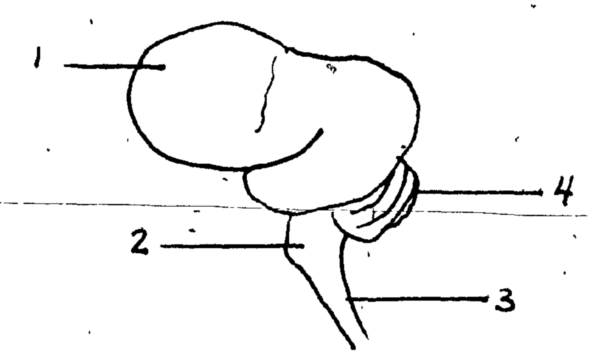
Appendix B

MIDSESSION TEST

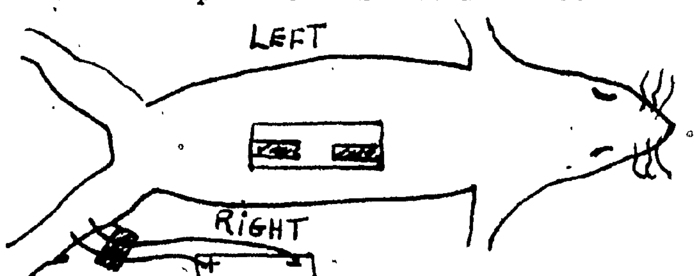
<u>Select the answer that best completes the statements. Write your answers on the sheet provided.</u>

1. From the diagram, identify the area where <u>ONLY MIXED</u> nerves are found.

   (a) 1 only.
   (b) 2 and 4.
   (c) 4 only.
   (d) 1 and 3.
   (e) 3 only.



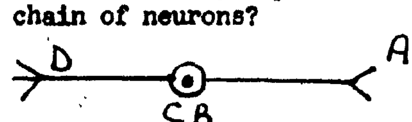
2. An anesthetized animal's spinal cord is cut as shown.



   Which statement is <u>true</u> if an electrical shock is given to the right hind leg?

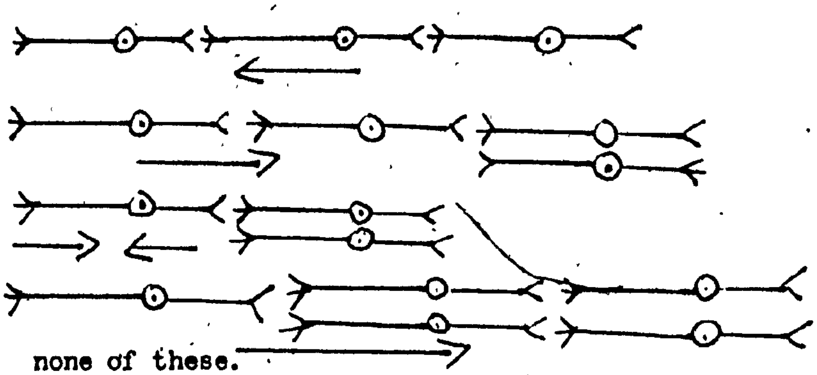
   (a) the animal will move its right front leg.
   (b) the entire body will jerk due to the shock.
   (c) the animal will not respond at all.
   (d) the right hind leg will respond due to a simple reflex.
   (e) the animal will respond voluntarily by moving both hind legs at the same time.

3. Which diagram correctly represents the passage of a nerve impulse along a chain of neurons?

   Legend: 

   Arrows indicate the passage of the nerve impulse.

(a)
(b)
(c)
(d)



(e) none of these.

4. The cerebellum is the center of:

(a) voluntary motor activities.
(b) intellectual faculties.
(c) muscular coordination.
(d) conscious activity.
(e) vision.

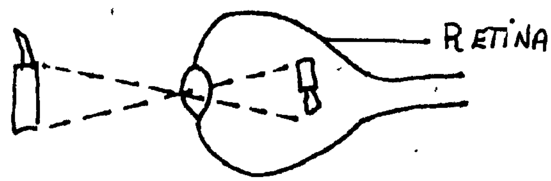
5. An accelerated breathing rate is usually accompanied by an accelerated heart rate due to the fact that the:

(a) bronchial tubes contain the nervous center accelerating the heart.
(b) the heart is compressed by the lungs.
(c) inflation of the chest cavity simultaneously enlarges the lungs and the heart.
(d) the diaphragm affects both the heart and the lungs at the same time.
(e) both the cardiac rate and respiratory rates are controlled by the same nerve center, the medulla oblongata.

6. If the human eye is compared to a camera, which part of the eye corresponds to the light sensitive film in the camera?

(a) the eye lid.
(b) the retina.
(c) the lens.
(d) the cornea.
(e) the iris.

7. Which visual defect is illustrated in the diagram?

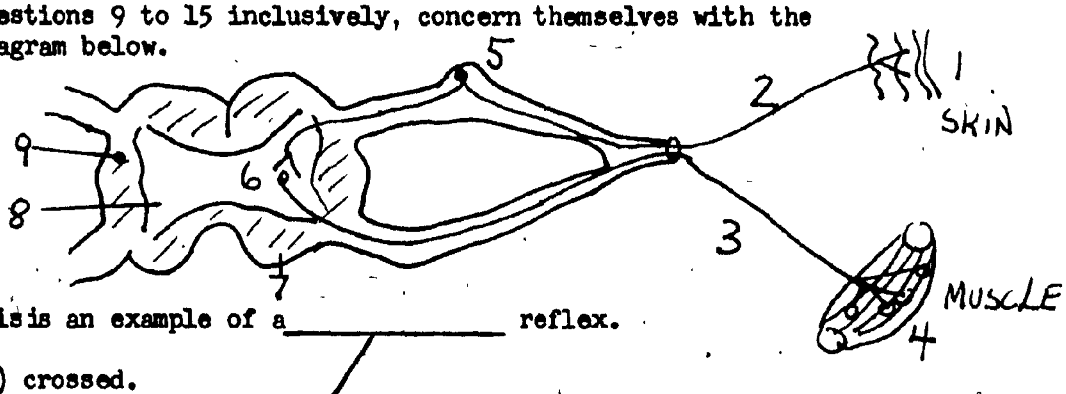


(a) presbyopia.
(b) hyperopia.
(c) glaucoma.
(d) cataracts.
(e) myopia.

8. A patient is received at an hospital clinic and the doctor asks for a lumbar puncture. This means that the doctor wants to:

(a) localize a fracture.
(b) take a kidney sample.
(c) anesthetize his patient.
(d) correct a lumbago.
(e) take a sample of the cerebrospinal fluid.

Questions 9 to 15 inclusively, concern themselves with the diagram below.



9. This is an example of a ____________ reflex.

(a) crossed.
(b) simple.
(c) compound.
(d) simple - compound.
(e) complex.

10. The reflex center is:

(a) 5 (b) 1 (c) 6 (d) 7 (e) 4.

11. The effector organ is:

(a) 1 (b) 2 (c) 7 (d) 4 (e) 5.

12. The dorsal root ganglion is:

(a) 5 (b) 7 (c) 1 (d) 6 (e) 3.

13. The afferent neuron is:

(a) 3 (b) 5 (c) 2 (d) 6 (e) 7.

14. The substance released at 4 is:

(a) H_2O (b) CO_2 (c) lactic acid (d) acetylcholine (e) CO.

15. The pathway of the nerve impulse is:

(a) 1-2-5-7-3.
(b) 4-3-6-2-1.
(c) 1-2-5-6-7.
(d) 1-2-3-4-5.
(e) 1-2-6-3-4.

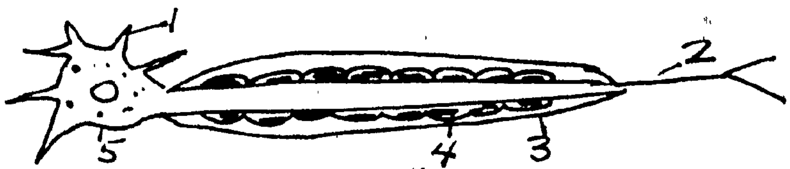
16. The image viewed by the eye is focused on the retina by the:

(a) lens (b) pupil (c) iris (d) fovea (e) cornea.

17. Neurons of the C.N.S., in general, do not regenerate:

(a) because they possess myelin.
(b) because they are paralyzed in an accident.
(c) because they cannot function unless they transmit a nerve impulse.
(d) because they lack neurilemma.
(e) because they control all involuntary motor reflexes.

18. In the given diagram select the cell body.



(a) 1 (b) 2 (c) 3 (d) 4 (e) 5.

19. From the same diagram, where would the axo-somatic synapse occur?

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5.

20. Which eye structures admit light?

1. cornea 3. iris 5. pupil

2. lens 4. retina 6. sclera.

21. In dim light, the pupil opening:

(a) narrows because the iris contracts.
(b) enlarges because the iris dilates.
(c) enlarges because the iris contracts.
(d) narrows because the iris dilates.
(e) does not change.

22. Which substance is necessary for color vision?

(a) cones (b) acetylcholine (c) iodopsin (d) rhodopsin (e) oxygen.

23. Which activity is controlled by the central nervous system?

(a) walking.
(b) digestion.
(c) perspiration.
(d) acceleration of heart beat.
(e) dilation of the pupil.

24. The frog's brain is destroyed but the spinal cord is kept intact. Its toes are pinched causing the palm to bend. The palm is then placed in ether, and the frog is again pinched. There is no reaction because ether has an effect on:

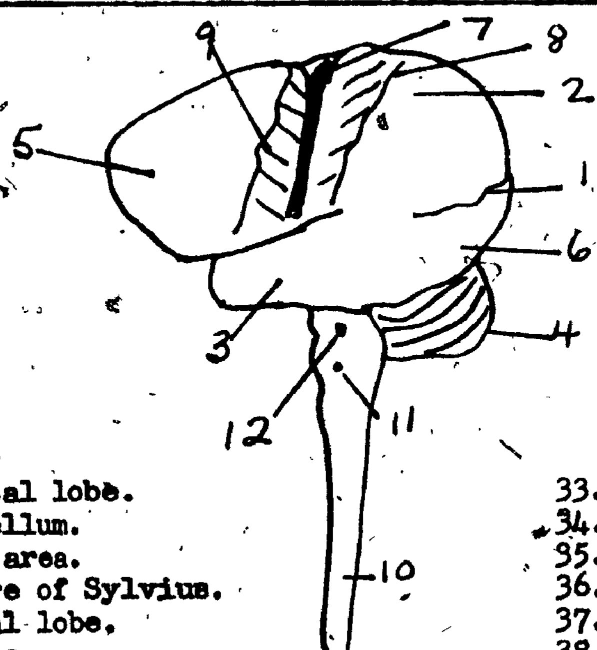
(a) sensory nerves.
(b) motor nerves.
(c) leg muscles.
(d) sensory receptors.
(e) nervous centers.

25. Spinal nerves are:

(a) sensory.
(b) motor.
(c) autonomic.
(d) mixed.
(e) voluntary.

Nos. 26 to 40 concern the diagram below. Give the answers as numbers.

Match the correct number in the diagram with the correct word or words.



26. parietal lobe.
27. cerebellum.
28. motor area.
29. Fissure of Sylvius.
30. frontal lobe.
31. medulla.
32. pons.
33. spinal cord.
34. sensory area.
35. occipital lobe.
36. hearing center.
37. tasting center.
38. Fissure of Rolando.
39. cardiac center.
40. origin of voluntary motor impulses.

MIDSESSION TEST

ANSWER SHEET

BIOLOGY 412

NAME: ______________________________

SCORE: ______ / 100

1. 21.
2. 22.
3. 23.
4. 24.
5. 25.
6. 26.
7. 27.
8. 28.
9. 29.
10. 30.
11. 31.
12. 32.
13. 33.
14. 34.
15. 35.
16. 36.
17. 37.
18. 38.
19. 39.
20. 40.

Appendix C

POSTTEST

INSTRUCTIONS: Answer all questions on the answer sheet provided.

PART I - Select the choice that best completes each of the following statements. 20 marks

1. Which of the following is true about a simple reflex?

   (a) it is an unlearned response.
   (b) it is a conditioned response.
   (c) it is a fully learned response.
   (d) it is a branching, tree-like nerve process that carries impulses toward the cell bodies.
   (e) it is the brain region that controls the activities of the internal organs.

2. The center for muscular coordination in the brain is found in the:

   (a) frontal lobe.
   (b) occipital lobe.
   (c) parietal lobe.
   (d) pons.
   (e) cerebellum.

3. The autonomic nervous system is chiefly responsible for:

   (a) the wrinkles in the cerebral cortex.
   (b) almost no activity in the body.
   (c) voluntary control of respiration.
   (d) involuntary control of our internal environment.
   (e) coordination of muscular activity.

4. The peripheral nervous system is basically made up of:

   (a) a system of nerve cell bodies.
   (b) afferent fibers and efferent fibers.
   (c) afferent, efferent and mixed nerves.
   (d) cell bodies and efferent nerves only.
   (e) afferent nerves, efferent nerves, mixed nerves and cell bodies.

5. The diagram below represents the typical nerve cell.
Which part of the nerve cell or neuron does the letter 'Y' represent?

(a) the axon.
(b) dendrites.
(c) the cell body.
(d) the myelin sheath.
(e) the neurilemma.

6. Conduction in neurons depends on:

(a) involuntary functions.
(b) movement of electrons as when current passes through a wire.
(c) an electro-chemical process which is self-propagating.
(d) a reflex arc.
(e) an entirely chemical process.

7. Colour vision results from the action of:

(a) the aqueous humour in the eye.
(b) the rods in the retina.
(c) the cones in the retina.
(d) the cornea.
(e) the rods and the cones in the retina.

8. The terminal branches of dendrites of sensory nerves in the skin are called:

(a) impulses.
(b) effectors.
(c) receptors.
(d) neurons.
(e) cranial nerves.

9. The part of the entire nervous system that plays a major role in coordinating the activities and functions of the human body is:

(a) the brain.
(b) the spinal cord.
(c) the brain and the spinal cord.
(d) the peripheral nervous system.
(e) the autonomic nervous system.

10. The image projected on the retina of the eye is:

(a) inverted and laterally reversed.
(b) upright and reversed.
(c) upright.
(d) usually blurred.
(e) none of the above.

11. The act of blushing is controlled by the:

(a) brain.
(b) autonomic nervous system.
(c) central nervous system.
(d) automatic nervous system.
(e) peripheral nervous system.

12. The semi-circular canals are associated with:

(a) hearing.
(b) balance.
(c) draining of fluid from the inner ear.
(d) swallowing.
(e) the sense of touch.

13. Olfactory nerves are associated with:

(a) touch.
(b) hearing.
(c) smelling.
(d) sight.
(e) taste.

14. Receptors are:

(a) reflexes with which one is born.
(b) nerve centers in the spinal cord.
(c) membranes on the surface of the spinal cord.
(d) specialized nervous tissue sensitive to changes in our surroundings.
(e) centers in the brain that receive nerve impulses.

15. Which of the following activity is controlled by the C.N.S.?

(a) walking.
(b) digesting.
(c) perspiring.
(d) accelerating the heart beat.
(e) dilation of the pupil.

16. In dim light, the pupil opening:

(a) enlarges because the iris dilates.
(b) narrows because the iris dilates.
(c) enlarges because the iris constricts.
(d) narrows because the iris constricts.
(e) does not change at all from its original position.

17. Nerve fibers conducting impulses away from the C.N.S. are:

(a) afferent fibers.
(b) association fibers.
(c) receptor fibers.
(d) efferent fibers.
(e) connecting fibers.

18. The dura mater is:

(a) a mixed nerve.
(b) a tough protective covering lining the vertebral canal and skull.
(c) a thin delicate covering of the surface of the brain.
(d) a membrane containing the blood vessels that nourishes the spinal cord and the brain.
(e) all of the above are true.

19. In the eye, which structures admit light?

1. cornea 2. lens 3. iris 4. retina 5. pupil 6. sclera.

(a) 1 and 5.
(b) 3, 4 and 5.
(c) 1, 3 and 5.
(d) 1, 2 and 3.
(e) 2, 3 and 6.

20. An example of a simple reflex action is:

(a) kicking a football knowingly.
(b) jumping when frightened.
(c) being cautious around a hot stove.
(d) walking.
(e) jogging.

PART II - Selecting structures from those listed below, list those involved in the simple reflex action of jerking a hand away from a hot stove. List the structures in the order in which they are affected. 10 marks

CEREBELLUM	______________ 1.
CEREBRAL CORTEX	
CRANIAL NERVE	______________ 2.
MOTOR NEURON	
MUSCLES OF ARM AND HAND	______________ 3.
PAIN RECEPTORS IN SKIN	
SENSORY NEURON	______________ 4.
SPINAL CORD	
	______________ 5.

PART III - Answer both questions in section 'A'. Answer only one question from section 'B'. Answer only one question from section 'C' also. Write all your answers on the sheet provided. 20 marks

SECTION A

1. Name the three main divisions of the nervous system and state the function of each.

2. Explain the fact that the sympathetic nervous system is sometimes called "the system for fight or flight".

SECTION B

3. Name the three ossicles of the middle ear and briefly discuss the function of these ossicles during the process of hearing.

4. Give the pathway followed by sound vibrations from the external ear or pinna to the temporal lobe cortex. Illustrate using a concept map.

5. What are the three main layers of the wall of the eye? What is the function of each one?

SECTION C

6. Explain why the cortex is convoluted.

7. How can the human eye adjust to focus clearly on an object in its field of vision?

8. Explain with the aid of a diagram the structural classification of neurons.

9. What are the two main properties of a neuron and explain each one?

POSTTEST

ANSWER SHEET

BIOLOGY 412

NAME: ______________________________

PART I - 20 marks

1.	11.
2.	12.
3.	13.
4.	14.
5.	15.
6.	16.
7.	17.
8.	18.
9.	19.
10.	20.

PART II - 10 marks

1.

2.

3.

4.

5.

PART III - 20 marks

SECTION A

1.

2.

SECTION B

SECTION C

Appendix D

QUESTIONNAIRE ABOUT THE CONCEPT MAPPING APPROACH

NAME: ______________________________

Please answer the following questions honestly and frankly.

INSTRUCTIONS

Following are some statements about the concept mapping approach. Please indicate the extent to which each statement characterizes the concept mapping approach by circling the appropriate response at the right of each statement. Also, please answer the two questions at the end of this questionnaire.

KEY: SD-strongly disagree; D-disagree; U-undecided; A-agree; SA-strongly agree.

1. The process of concept mapping lets you interact with the biology curriculum in a better fashion than other methods you have been exposed to.

   SD D U A SA

2. The technique of concept mapping is a simple way of reconstructing biological statements.

   SD D U A SA

3. Concept mapping helps you to reach an understanding of the subject matter through clear relations of concepts, and consequently helps you to learn better.

   SD D U A SA

4. Concept mapping is very good at organizing and directing your thinking and your sense of what is going on.

   SD D U A SA

5. When using concept mapping, the content that you have seen so far seems to be more meaningful.

   SD D U A SA

6. This method will probably allow you to achieve better grades in biology tests.

SD D U A SA

7. The concept mapping approach does not seem to be very useful for a subject like biology.

SD D U A SA

8. You prefer concept mapping to other teaching methods because it gives you more freedom to work individually.

SD D U A SA

9. Concept mapping is an acceptable method because it helps you to link biological facts with records and events.

SD D U A SA

10. Concept mapping is a desirable approach only when the teacher constructs concept maps.

SD D U A SA

11. Concept mapping is preferable when only you, the student makes use of it.

SD D U A SA

12. A combination of both teacher-made maps and student-made maps represents a better alternative for instruction.

SD D U A SA

13. What do you like about the concept mapping approach?

14. What do you dislike about the concept mapping approach?

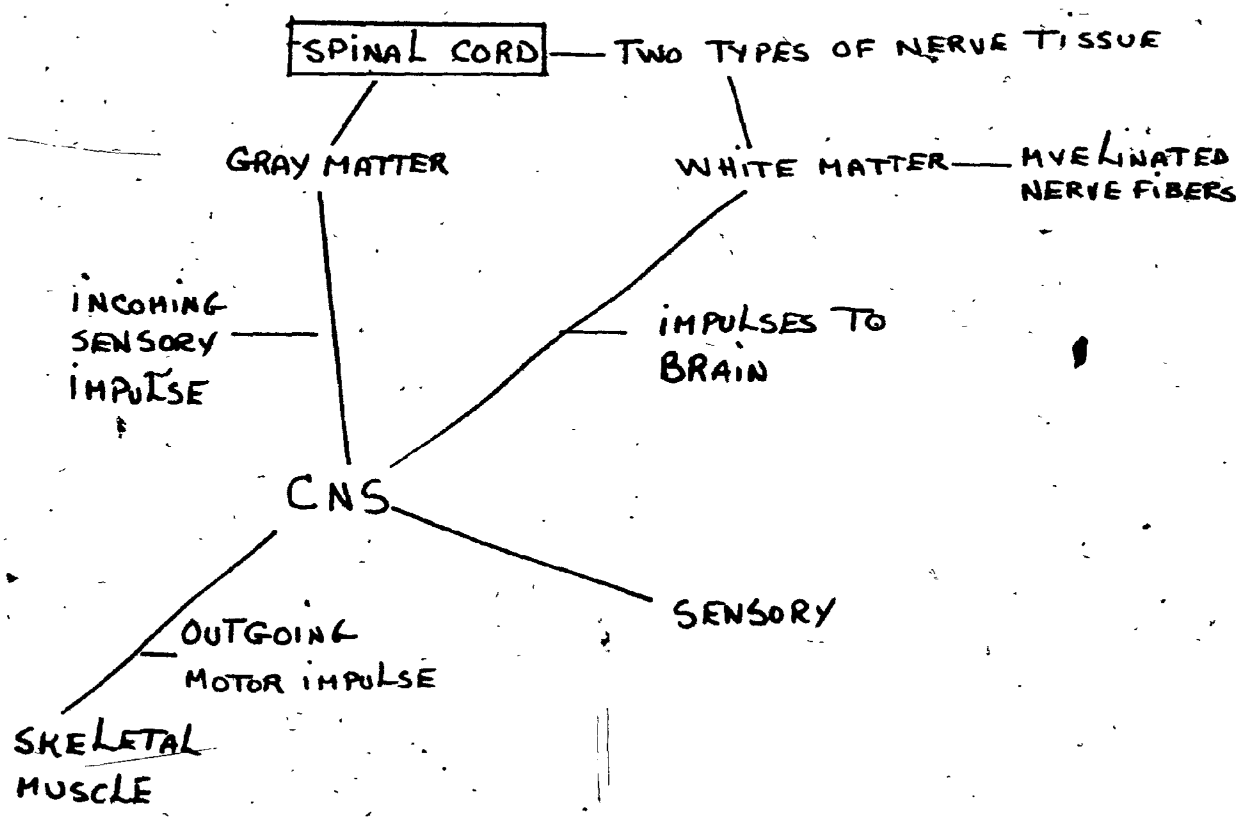
Appendix E

MEAN RESPONSE ON THE AFFECTIVE QUESTIONNAIRE FOR EACH READING LEVEL

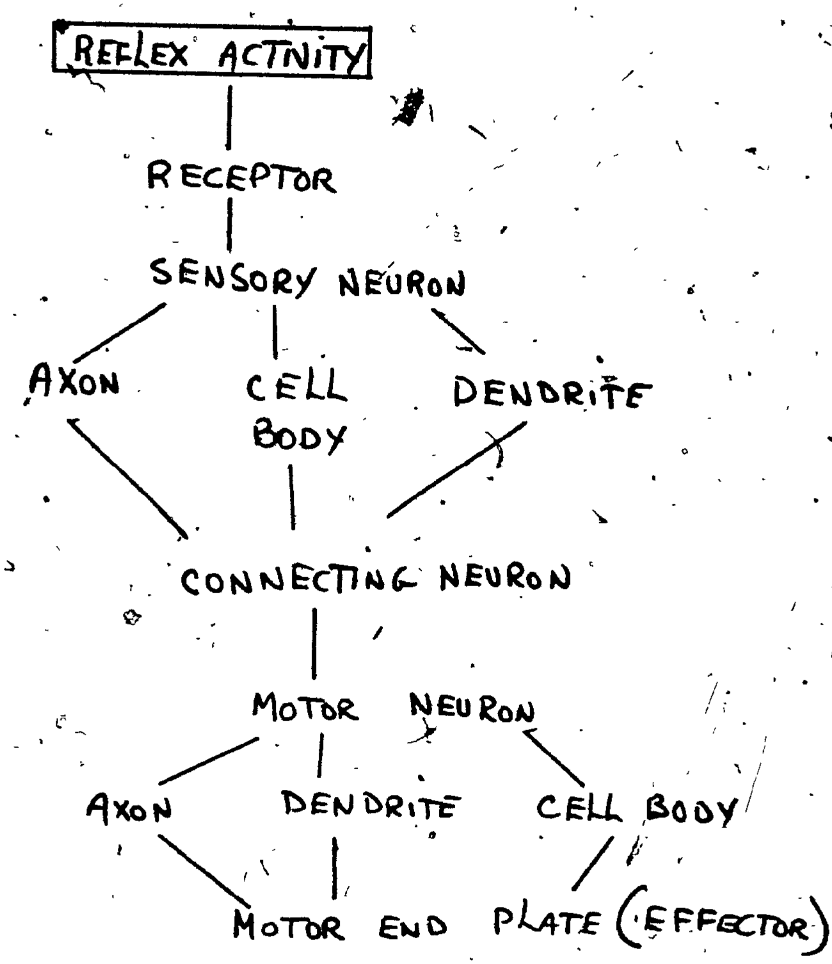
	READING LEVELS		
QUESTION	LOW	MEDIUM	HIGH
1	3.40	2.60	2.60
2	4.10	3.70	3.50
3	3.12	3.10	3.60
4	3.50	3.00	3.50
5	2.00	2.80	3.00
6	2.60	2.40	3.00
7	3.60	3.20	3.30
8	2.00	2.60	3.50
9	2.75	3.10	3.50
10	2.75	2.80	2.80
11	1.90	3.10	3.00
12	3.10	2.60	2.80

Appendix F

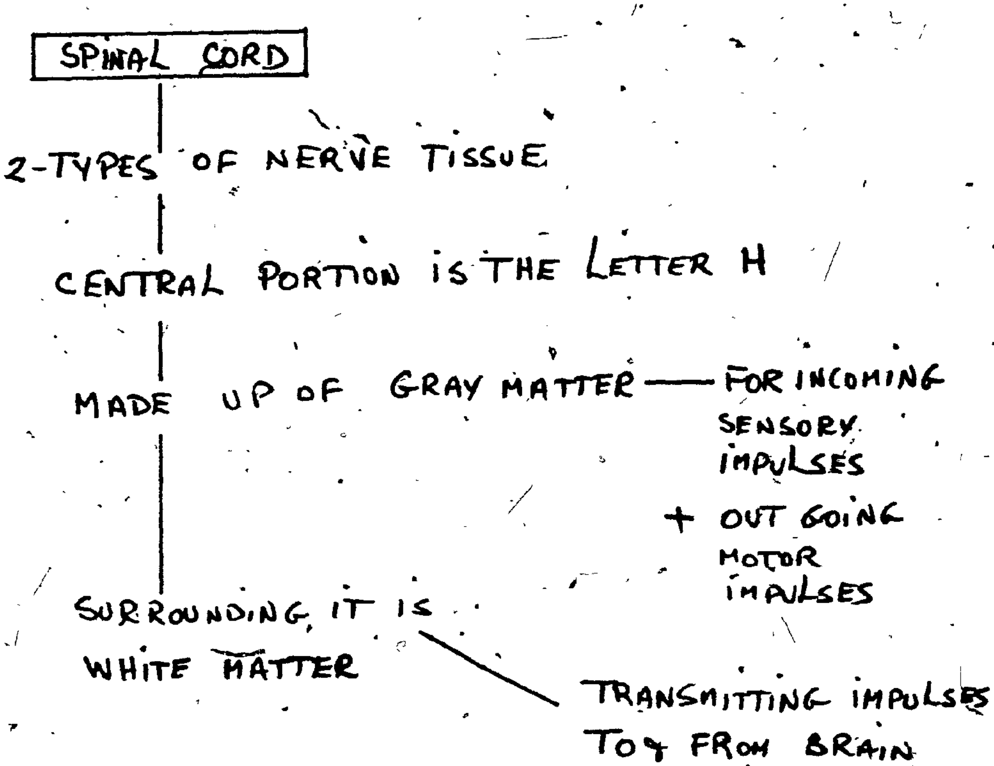
A CONCEPT MAP OF A LOW READING ABILITY STUDENT



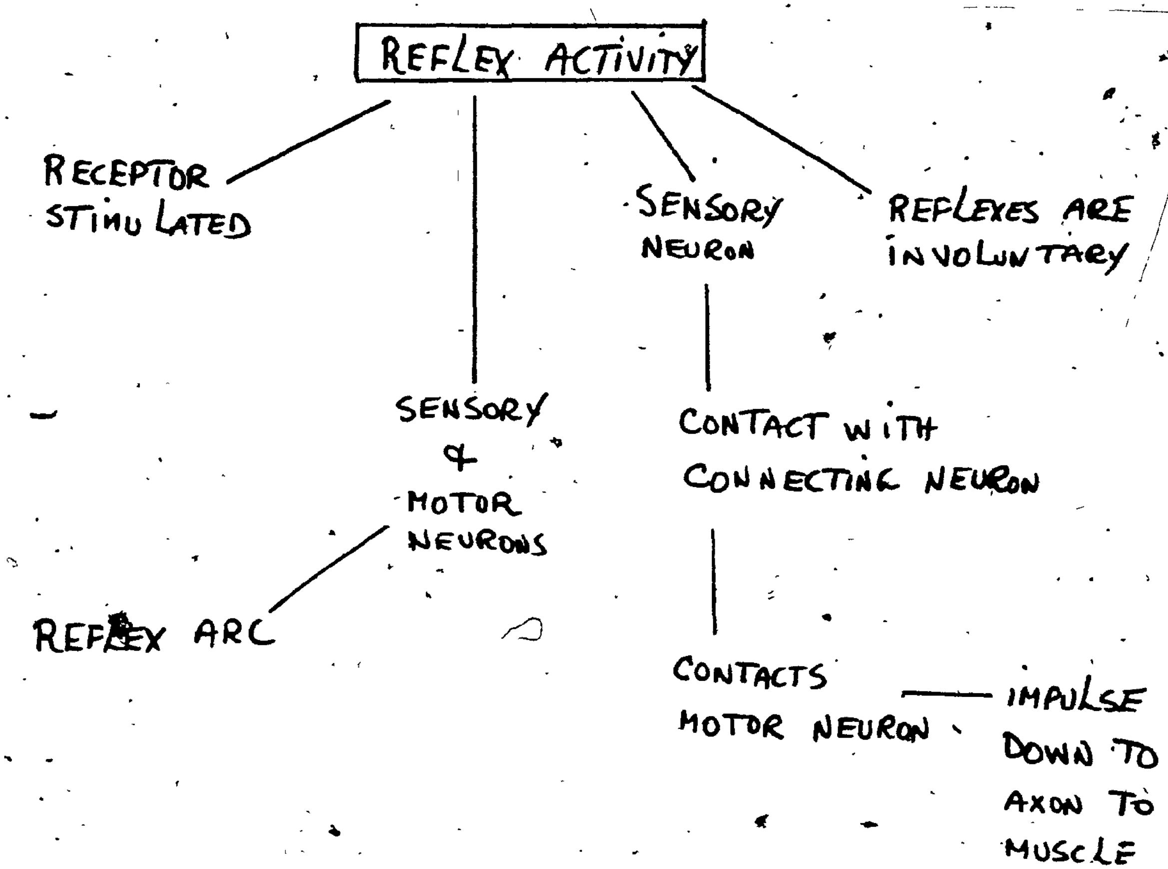
A CONCEPT MAP OF A LOW READING ABILITY STUDENT



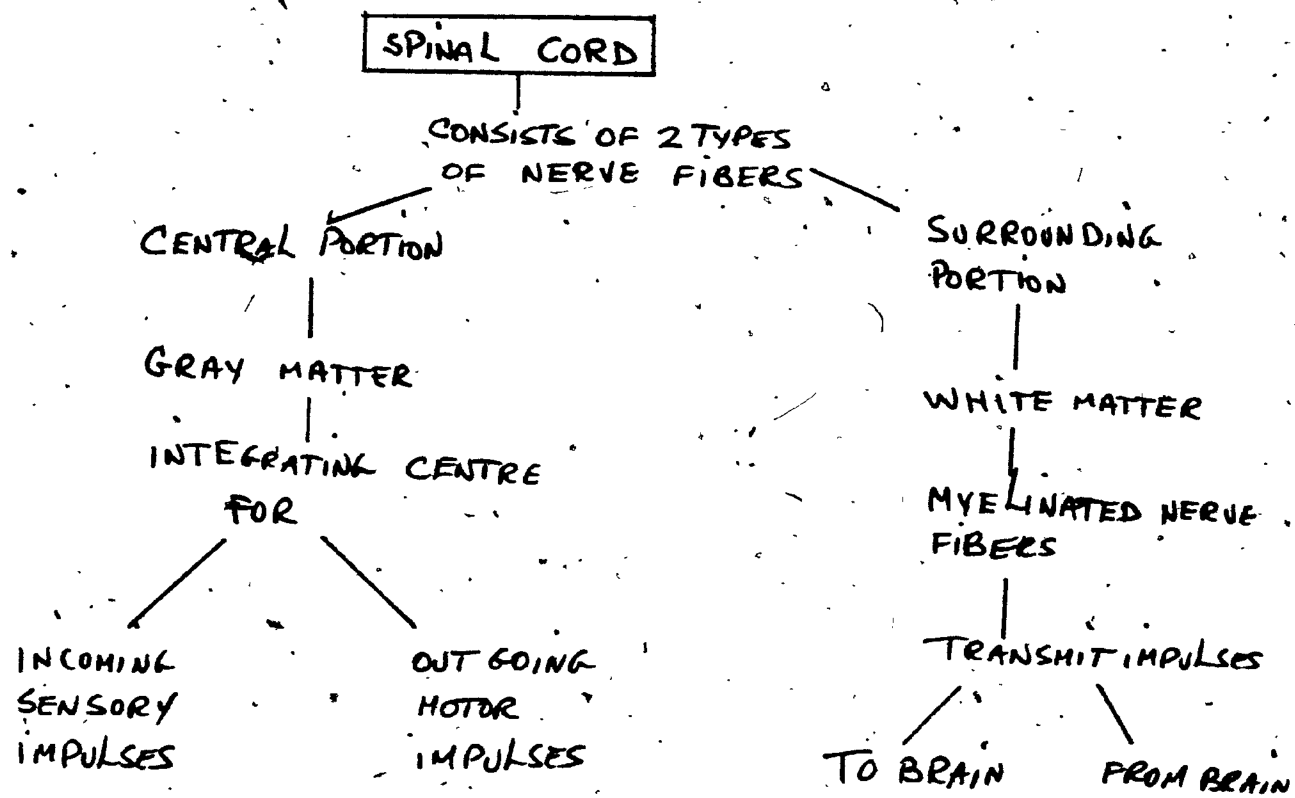
A CONCEPT MAP OF A MEDIUM READING ABILITY STUDENT



A CONCEPT MAP OF A MEDIUM READING ABILITY STUDENT



A CONCEPT MAP OF A HIGH READING ABILITY STUDENT



A CONCEPT MAP OF A HIGH READING ABILITY STUDENT