Effects of Learning Approach and Cognitive Mapping on Quality of Learning Outcome

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ABSTRACT

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Improving student learning skills has been an issue of ongoing concern and increasing urgency. This study draws from research on individual differences in learning to address this issue. Qualitative differences in students' approaches to learning have been found to result in qualitative differences in learning outcomes; our interest is in modifying a student's learning approach to improve learning outcome.

The focus of this study was to investigate whether less effective students who typically adopt a surface approach to learning (associated with the intention to reproduce essential information and the use of rote learning) can benefit from instruction in cognitive mapping to attain a meaningful learning outcome in a text comprehension task. Also examined was the effect of cognitive mapping on the performance of students whose typical approach is deep (learners who focus on the meaning inherent in learning tasks and look for interrelationships). In addition, the study investigated the overall effectiveness of the cognitive mapping strategy in increasing meaningful learning outcomes.

Six intact classes were randomly assigned to treatment or control conditions. Students were classified on learning approach according to Learning Process Questionnaire (LPQ) scores. The treatment group was provided instruction in a cognitive mapping strategy intended to help learners interrelate ideas in text passages. The dependent measure consisted of categorization of written responses to an essay-type test, using the Structure of Observed Learning Outcome (SOLO) Taxonomy to differentiate deep from surface responses.

A chi-square analysis demonstrated the effectiveness of cognitive mapping instruction on the performance of the treatment group as a whole ($p<.01$). Additional planned comparisons using Fisher's Exact Test, however, revealed that such instruction did not affect the performance of learners categorized either as surface or deep. Learners classified as neither deep nor surface (54% of the sample), on the other hand, were shown to be positively affected. Learners characterized as deep may be able to assimilate different deep strategies without ill effect, while learners categorized as surface may require other interventions if they are to develop understanding. Learners without a predominant learning approach may be most likely to benefit from this type of intervention.

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CHAPTER ONE

Introduction

Rationale

The idea of learning how to learn has long been of interest to scholars and practitioners alike. From Rousseau's concern with developing methods of learning distinct from formal teaching, as expressed in *Emile* (1762/1974), to the concern of many of today's educators, anxious to prepare students for the demands of a rapidly changing and complex society, we see continuing evidence of attention being directed to the need for improving the ability of students to learn. With the growing acceptance of the concept of lifelong learning, this need becomes even more critical. As Weinstein and Mayer (1986) have noted :

> Helping students to develop effective ways to handle the barrage of information coming from the environment, as well as our thinking processes, is a major goal of our educational system that will only increase in importance in the future. (p. 315)

Similarly, Corno and Snow (1986) have stated:

> Especially in a rapidly changing society, the promotion of aptitudes for learning, problem solving, and future problem finding takes precedence over the teaching of today's facts and skills as a central role for education. Effective learning-to-learn and transfer, not just effective learning, is the goal. (p. 606)

According to Biehler and Snowman (1993), the available research demonstrates that most children and adults are inefficient learners. In this study, our interest is in addressing the increasingly critical, yet basic, issue of how to assist less skilled learners in improving their learning skills so as to improve not only performance in school, but also, ultimately, in society.

With this focus on the improvement of learning skills, this study is of direct relevance to the aims of Educational Technology, which, as expressed by the Council for Educational Technology in the United Kingdom, is concerned with "the development and application of systems, techniques and aids *to improve the process of human learning*" [italics added].

Context of the Problem

Many interpretations of the term *learning to learn* exist in the literature (e.g., Dearden, 1976; Joyce, 1981). These include equating the concept of learning-to-learn with specific study skills, such as learning how to memorize; or with self-directed learning; or, more recently, with becoming "metacognitively sophisticated" (West, Farmer, & Wolff, 1991).

Despite the various interpretations, there appears to have been general agreement in the past on (a) a common focus, namely, skills for success in learning and education-related activity (Smith, 1987), and (b) the approach schools should take in responding to the need, which has generally been to offer courses in "study skills" (cf. Nisbet & Shucksmith, 1986). Within the realm of formal education, such courses have been in existence in North America at least since 1894, when Wellesley College provided its first study skills course (McKeachie, 1988).

Although a number of systems for effective studying have been proposed (Anderson, 1980), the content of study skills courses has traditionally had a focus on overt behaviours or study habits or on specific techniques such as speed-reading (Entwistle, 1987). The effectiveness of these systems has rarely been empirically studied (Goetz, 1984). The frequently cited "SQ3R" (Survey-Question-Read-Recite-Review) method (Robinson, 1970), for example, has received little attention from researchers. Anderson and Armbruster (1982) found no more than seven studies of the technique which, when reviewed, proved to be inconclusive, failing to provide empirical support for the method (Baine, 1986).

Texts on the subject of learning skills, including how-to-study manuals, have remained consistent in this type of content over the years. For example, advice found in Monroe's *Training in the Technique of Study* (1924), on such matters as how to establish an environment conducive to studying, is similar to that found in thirty-eight how-to-study texts summarized by Laycock and Russell (1949), and can likewise be found in current study manuals (Nisbet & Shucksmith, 1986).

Although much effort has been expended in providing formal instruction in study skills, the results do not show evidence of much success in the actual improvement of students' abilities (Entwistle, 1987; Lochhead, 1979; Mayer, 1987a, 1988; Ramsden, 1985). In explaining this lack of evidence, Nisbet and Shucksmith (1986) have included the following in their summary of criticisms directed at the general approach undertaken in such instruction:

> 1) It lacks a theoretical basis, having no links with developments in cognitive psychology.
>
> 2) It lacks an empirical basis, being based on a self-perpetuating consensus.
>
> 3) It is often too general and out of context, so that it is not seen by learners as relevant to their needs and so is not applied.
>
> 4) It is not transferable, being often a collection of tips for coping with specific subject-based procedures.
>
> 5) It can too readily become merely a way of coping with the formal requirements of the school system, particularly with passing examinations. (p. 23)

Traditional study skills research has not really had much to offer either theorists or practitioners (Anderson & Armbruster, 1984). This research has usually consisted of the documentation of external behaviors thought to be associated with "good" study methods (Christensen, Massey, & Isaacs, 1991). Commonly used inventories, such as the Survey of Study Habits and Attitudes (Brown & Holtzman, 1955), were based on the assumption that demonstrating "model behavior" consisting of a specific collection of good study habits would ensure academic success across all learning contexts. Activities such as taking careful notes and setting aside regular study periods free from distraction have been assumed to represent such model behaviors of study (Watkins & Hattie, 1981). Such approaches are still very much in evidence (Entwistle & Waterston, 1988; Rohwer, 1984).

Studies have failed, however, to validate these activities as effective study behaviors. Instead there is evidence that successful students do not necessarily demonstrate such behaviors, while failing students may in fact exhibit them (e.g., Lafitte, 1963; Maddox, 1963; Schmeck & Grove, 1979). Reviewers of such studies have concluded that the overt behaviors traditionally associated with "good" study habits do not serve to distinguish effective students from ineffective ones (Biggs, 1978; Entwistle, Nisbet, Entwistle, & Cowell, 1971).

In general, applied research in the area has not been successful in providing evidence of effective study methods which could be of practical use to students. Goetz (1984) has attributed this failure to the traditional separation of basic research, applied research, and educational practice. According to Lochhead (1979), answers to such basic questions as the following would have dramatic effects on educational practice: "How can general learning and problem-solving skills be taught?" and "What learning and reasoning skills do students actually employ and how are these affected by instruction?" (p. 5)

Current research efforts in the area of learning-to-learn reveal the influence of cognitive approaches; the traditional outward behavioral focus is being replaced by a focus on internal processes within the learner. Other relevant changes resulting from this new perspective include shifts in emphasis from viewing cognition (a) as a part-to-whole mechanism to a holistic or systemic mechanism, (b) from a direction of concrete to abstract, (c) as a discovery/retrieval process to a constructive process, and (d) as outcome-focused to process-focused (West et al., 1991). As a result of this redirection, investigators have been reformulating their research questions.

The change in focus has resulted in the growth of research in learning strategies, much of which does integrate basic research, applied research and educational practice; and which focuses on the learner as a "central and active agent" (Goetz, 1984). As defined by Weinstein and Mayer (1986), learning strategies are "behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process" (p. 315). This encoding process is comprised of those cognitive processes involved in the selection, organization, and integration of new information. Research in cognitive strategies has shown that the cognitive skills involved are affected by many factors, such as subject, task, attitudes, and contextual variables (Hartman and Sternberg, 1993).

Weinstein and Mayer (1986) have noted the usefulness of research in creating a database for applied use, making specific reference, in this regard, to the need expressed by certain researchers (e.g., Segal, Chipman, & Glaser, 1985) to make instruction in learning strategies as explicit as possible, especially for the less skilled learner.

Our selected research problem in this study addresses precisely this need. Drawing on current research, we will test the effectiveness of such explicit instruction in a specific strategy to improve the performance of the target group we have defined as less skilled learners.

Promoting Meaningful Learning

In addressing the general research problem, we choose here to focus on the ability to achieve *meaningful learning* as the characteristic differentiating skilled learners from those less skilled. Such learning is attained through the process of understanding, in contrast to *rote learning*, attained through the process of memorization (Ausubel, 1968; Säljö, 1982).

In contrasting the result of rote learning with that of meaningful learning, Di Vesta (1987) has provided us with a useful comparison:

> Such knowledge is relatively inert. Often it is unrecognized in a similar form only a few months after

it has been learned. On the other hand, domain content or domain procedures that are understood have been assimilated into the person's knowledge structures. As a consequence, such knowledge is capable of being activated: that is of signaling interpretation, of being used and recognized in paraphrase, and of activating related knowledge for other generative processes (Wittrock, 1974, 1978) including problem solving and prediction. (p. 205)

We are interested in promoting such meaningful learning, characterized by understanding and assimilation into the learner's existing knowledge structures. A body of research studying differences in *approaches to learning*, based on a phenomenological perspective, and originating at the University of Gothenborg in Sweden, provides us with a useful starting point.

In relating their findings concerning differences in the approach to a learning task to differences in outcome, these researchers found a definite pattern. Whether a person used a *deep* or a *surface approach* to learning appeared to significantly affect learning outcomes when these outcomes were described in qualitative terms. The research revealed that "people employing a deep approach have been found to display better comprehension of the intentional content of written materials, while a surface approach often results in 'missing the point' of what has been read" (Säljö, 1982, p. 54).

Subjects using a deep approach in a reading task were described by Marton (1975) as: (a) concentrating on the meaning of the discourse, and (b) actively making connections within the text. This stands in contrast with subjects using a surface approach, characterized as: (a) concentrating on the surface aspects of the discourse and the task at hand, and (b) displaying a passive approach by not making associations.

Given that we ascribe value to a deep approach to learning, we can express our research goal in terms of finding a means of assisting learners to adopt a deep approach. According to Ramsden (1988), a critical educational question can be expressed as "how to present tasks so as to engage the student at a deeper level" (p. 163). An alternative perspective on this question, based on an interest in providing the student with greater leverage in controlling his or her own learning, allows us to rephrase the question and ask "how can we enable students to engage themselves in tasks at a deeper level".

The cognitive strategy research literature on expert-novice differences provides us with evidence that superior performance is mediated by the use of better strategies (Britton & Glynn, 1987; Gallini, 1989; Pressley, 1986; Pressley, Borkowski, & Schneider, 1987). If we adopt the position that a deep approach, within the context of meaningful learning from text, results in superior performance, then it becomes relevant to determine how to make this approach accessible to more learners.

In general, despite theoretical links, research in learning approach differences has not resulted in a practical application of helping students develop effective learning strategies, as Ramsden (1985) noted:

> Descriptions by researchers of qualitatively high approaches to learning - e.g., of "deep-level processing" or of "versatility" - can provide well-defined criteria of outcomes and indicate characteristic styles or strategies to which they are linked. Qualitatively low descriptive categories, on the other hand, can help in the identification of weaknesses in the way students tackle learning tasks but generally provide little indication of how these can be overcome. (p. 112)

We are interested in addressing this gap by identifying a means for learners who typically rely on a "qualitatively low" approach to learning to acquire a "qualitatively high" or deep approach. We propose that enabling learners relying on non-deep approaches to apply strategies characteristic of a deep approach would be beneficial to these learners.

Mental Representations of Text

In actively making connections within the text they are studying, learners with a deep approach "build internal connections in the new material" (Ramsden, 1985, p. 112), searching for a way to link main points. In applying a cognitive framework to this "building" process, we can describe the result as a form of internal knowledge representational system within the learner, that is, a *mental representation*.

Mental representations have been variously referred to in the research literature by different terms, including *schema* (e.g., Bartlett, 1932; Rumelhart & Norman, 1983), *state schemata* and *process schemata* (West et al., 1991), and *internal representations* or *mental models* (e.g., Bruner, 1966; Gentner, 1983; Gentner & Stevens, 1983; Johnson-Laird, 1983; Mayer, 1975; Norman, 1983; Winograd & Flores, 1987).

Concern with mental representations as "organized knowledge structures" (Gagné, Yekovitch, & Yekovitch, 1993) has figured prominantly in cognitive research over the past 20 years, but has only recently surfaced in research specifically focusing on knowledge acquisition from text. The construction of mental representations is now being regarded as critically important in this form of knowledge acquisition process (Flammer & Luthi, 1991; Resnick, 1990). The goal of the reader can be stated quite simply as that of building a mental representation of the text. Research in text processing has demonstrated the inadequacy of previous approaches, such as those based solely on linguisic knowledge or textual structures, in explaining how knowledge is acquired from text (Denhière & Baudet, 1989).

In discussing the inferential and interpretive processes involved in the construction of mental representations, Resnick (1990) has noted that research in cognitive theory suggests that these processes:

> traditionally reserved for advanced students - that is, for a minority who had developed skill and taste for mental work - might be taught to all readers, . . . especially, those who learn with difficulty. These processes, cognitive researchers are saying, are what we mean by reading skill. (p. 696)

Such processes may be considered "automatic" for "skilled readers" (Resnick, p. 696). or, as defined in our context, for learners typically employing a deep approach. In our interest to improve the skills of learners relying on surface approaches, it is then relevant to consider processes that would facilitate construction of mental representations, namely those that affect the building of internal connections.

Cognitive Mapping

Specific instruction in certain organizational strategies can facilitate the building of internal connections among ideas (Weinstein & Mayer, 1986). These strategies describe a subset of a more general set of learning strategies referred to as techniques "that a learner can be taught to use during learning" (p. 315). Of particular relevance are those organizational strategies which influence a key component of the encoding process, referred to by Weinstein and Mayer as "construction", that is, the "building of connections between ideas that have reached working memory" (p. 317).

Mapping strategies which require learners to identify and link ideas in a physical representation have been shown to be useful in various applications requiring the building of a coherent structure of ideas (e.g., Buckley & Boyle, 1983; Buzan, 1982; Deshler, 1990; Novak, 1990; Novak & Gowin, 1984; Rowntree, 1979; Singer & Donlan, 1989; Wycoff, 1991). Whereas we have referred to the internal result of building connections as mental representations, we will refer to the externalization of these connections in a physical representation as *cognitive mapping*. Eden, Jones, and Sims (1983) have referred to cognitive mapping as "a modelling technique which intends to portray ideas, beliefs, values and attitudes and their relationship one to another in a form which is amenable to study and analysis" (p. 39).

Cognitive mapping has been found to be useful as a learning strategy in a variety of contexts. *Concept mapping*, for example, as a means to schematically represent domain structures has been found to be of benefit to students as young as seventh graders (Novak, Gowin, & Johansen, 1983). Within the last decade cognitive mapping strategies have been applied specifically to the understanding of text, and are referred to within this context by some researchers as *spatial learning strategies* (e.g., Brueker, 1984; Holley &

Dansereau, 1984a; McKeachie, 1984). Studies employing various mapping techniques have provided some empirical support for the effectiveness of this strategy in learning from text (e.g., Armbruster & Anderson, 1980; Barron & Schwartz, 1980; 1984; Berkowitz, 1986; Holley, Dansereau, McDonald, Garland, & Collins, 1979; Mayer 1984; Singer & Bean, 1984; Vaughan 1982, 1984). Although the differing methodologies behind these strategies result in different types of representations (varying in organizational structure, types of relationships depicted, and use of labels describing relationships), the strategies share the objective of visually representing important relationships among ideas in a passage of text.

By requiring the learner to generate spatial representations of the information presented in text and thus construct an external model of the content, mapping strategies require the learner to focus on the structure of the text and to make explicit the relationships among ideas. These strategies are thought to have more potential than others in tasks requiring meaningful learning from text as they "force students to identify or impose relationships that convey the meaning of text" (Anderson & Armbruster, 1984, p. 673).

An area of difficulty identified in the use of these strategies is the amount of time and effort required by students to acquire competence in their use and to practically apply them in the completion of routine school assignments (Anderson & Armbruster, 1984; McKeachie, 1984, 1988). The reason is that most of these strategies require the student to engage in specific activities, such as the categorization of linking relationships, which impose a heavy processing burden on the mental operations of the user and require additional time to learn and apply. Although the available research provides evidence that the strategies can indeed serve as important aids to learning, the fact that students require a great deal of practice in automatizing them (approximately 12 to 24 hours) and in applying them after they have been automatized seriously detracts from their appeal (McKeachie, 1988).

A simplification of the routines employed may reduce the mental load implied in the use of these strategies, without detracting from the benefits. We have seen, for example, that the technique of *procedural facilitation*, which consists of "routines and external aids designed to reduce the processing burden involved in taking on the advanced self-regulatory strategies of the expert" (Scardamalia & Bereiter, 1986, p. 70), has been successfully used in the teaching of writing (e.g., Scardamalia & Bereiter, 1983). Such simplification, applied to cognitive mapping strategies, may make these strategies more accessible to learners.

Our interest in operationalizing the strategies of a learner using a deep approach is to assist others in the activity of building connections between ideas in the formulation of mental representations. Our emphasis is on the need for the learner to focus on the *connectedness* of ideas, rather than on the need for the learner to correctly name specific relations between ideas. The latter requires training in the ability to categorize the types of links made and to make the correct links. We therefore propose a simplification of procedures that would focus primarily on the linking of ideas presented in a passage of text.

Individual Differences

The growing body of research related to cognitive mapping, including its application to text comprehension, provides increasing evidence of its potential effectiveness as a learning strategy (McKeachie, 1988; Novak, 1990; West et al., 1991). This research, however, at the same time provides some indications that individual differences may play a role in determining how effective a cognitive mapping strategy may be for each learner.

Of interest are the results of a key study, in which Holley, Dansereau, McDonald, Garland, and Collins (1979) found that students trained in the use of a *networking* mapping strategy, performed better than control students on the task of remembering main ideas. Of particular interest is the finding that students with low grade point averages (GPAs) demonstrated the greatest improvement as a result of training. The researchers have suggested that the students with high GPAs already possessed effective learning strategies prior to the study and these served to compete with the new strategy. A body of research exists supporting the notion that performance in high-ability performers is hindered "by imposition of strategies that are incongruent with the learner's own (already efficient) tactics" (Dillon, 1986, p. 9).

Other research related to cognitive mapping also suggests the importance of the role of individual differences. Schmid and Telaro (1990), for example, found concept mapping to be beneficial to learners with lower reading ability, who outperformed non-mapping, lower ability readers on the completion of a multiple choice test, and performed at par with higher ability readers in both mapping and non-mapping conditions. Higher ability readers found concept mapping to be initially disruptive. Naidu (1991), also found evidence of individual differences with respect to the level of "persistence" of subjects in completing concept mapping exercises and in their performance on certain measures of outcome.

Few studies have investigated the role of individual differences in learning strategies, although the need to do so is widely acknowledged (Richardson, 1983; Spiro & Myers, 1984; Sternberg, 1986). Schmeck (1988b), for example, has recommended that "learning strategies training and research programs should routinely include individual difference measures. The objectives would be to study and take advantage of interactions between personal attributes and the treatments used in training" (p. 171). In supporting the value of such research, Spiro and Myers (1984) have contended that the results of this research are valuable and, for example, could provide evidence that "one study technique might be better for individuals who tend to represent information in a highly compartmentalized form, while another is better for individuals whose knowledge structures are characterized by high connectivity" (p. 488).

One source of individual differences in performance on learning tasks may be attributed to the student's learning approach, a variable not investigated in the previously mentioned studies. The impact of using a cognitive mapping strategy on a learner's performance may differ with respect to the individual's approach to the learning task, that is, whether the individual typically uses a deep or a surface approach.

In placing the current study within a framework which takes into consideration research focusing on the relationship between individual differences and instructional treatments, we may refer to the body of aptitude-treatment interaction (ATI) research of the last 25 years. These studies usually relate traditional psychometric measures to variations in instructional treatment (Gagné, 1989). According to Corno and Snow (1986), ATI research, as generally concerned with "adaptive teaching", can be broadly said to focus on research problems relating to either circumvention of inaptitude or aptitude development. Snow

(1989) has described ATI research on learning and instruction as placed "within the broader perspective of person-situation interactionism in psychology, of which it is a special case" (p. 15).

Aptitude may be simply described in terms of the initial properties of the learner which interact with learning (Glaser, 1967; Cronbach, 1967; Snow, 1989). In past research, aptitude variables have included ability, personality dimensions, and cognitive style. The goal of matching instructional treatment to aptitude stands in marked contrast to the goal of developing the learner's ability to learn (Henderson, 1984).

The view of what the initial learner properties entail has evolved during the course of ATI research to take into consideration additional complexity. In looking at the future direction ATI research should take, Snow (1989) has noted the increasing evidence that the intentions of the learner play an important role in determining learning outcomes. These intentions have been specifically identified in terms of learning approach differences (i.e., deep and surface approaches), which can be linked to relatively stable aptitude variables. In view of their importance, Snow has recommended that it is crucial for future ATI research to focus its efforts on "cognitive-motivational-intentional styles" in order to address the higher order interactions that characterize the instructional context (p. 51). Insofar as the current study relates to these ATI issues, it can be said to be aligned with the most current concerns expressed in the field.

Purpose of the Study

In this study we are broadly interested in determining how to help less skilled students develop effective learning strategies. Our ultimate goal in this research is to provide teachers with a practical means of identifying and addressing weaknesses in learning approach.

Specifically we are interested in investigating a strategy that learners could adopt to ensure meaningful learning, which we have defined as being characterized by the building of connections between ideas, e.g., in the construction of mental representations resulting in the ability to convey the substance of a text passage. This activity is described as occurring naturally in learners using a deep approach to learning tasks.

Within the context of learning from text, we would like to test the effectiveness of applying a cognitive mapping strategy which requires learners to physically link ideas while constructing a representation of a text passage. The focus of this study therefore is to investigate whether students whose typical approach to learning is surface, that is, whose tendency is to rely on rote learning strategies, can benefit from instruction in such a cognitive mapping strategy to attain a level of meaningful learning in a text comprehension task.

In a broader exploration of the issue of how individual differences interact with learning strategies, we are also interested in the effect of applying a specific cognitive mapping strategy on the performance of learners typically using a deep approach to learning tasks. Such learners, by definition, already possess effective learning strategies to achieve meaningful learning. We are interested in determining whether or not the application of a new learning strategy impedes the performance of these learners, insofar as it may interfere with existing strategies.

As our goal is to promote meaningful learning, we will evaluate learning outcomes in terms of dependent measures that are sensitive to changes in understanding, that is, qualitative measures of learning.

We are also interested in investigating the effectiveness of a cognitive mapping strategy employing a more simplified approach than other mapping strategies aimed at acquiring knowledge from text. Requiring a less intense procedural focus, this strategy will emphasize the student's activity of building connections between ideas instead of categorizing relationships between ideas. This will result in decreasing instruction time and task time, as well as simplifying the objective of the activity, thus increasing the accessibility of the strategy to students, without detracting from its benefit as a learning aid.

The purposes described in this section serve as the basis for the theoretical hypotheses to be presented at the end of Chapter Two, "Review of the Literature," and operationalized in Chapter Three, "Methods."

Significance of the Study

The results of this study will contribute to the body of research on learning strategies, primarily through its focus on the issue of individual differences. At the same time the study will help provide a practical application for research in learning approaches, which has yielded little by way of providing specific means of addressing weaknesses in how students approach learning tasks.

Greater understanding of how a student's approach to learning may affect the application of learning strategies has very practical implications regarding their use in the classroom. As Schmeck (1988b) has recommended, we need the following information to help us optimize each learner's specific ability to learn:

> We need to know what types of students are most receptive to what types of tactics. We need to know which tactics are slightly "out-of-character" for a particular student, but close enough to produce some accommodation or growth in style or personality. (p. 187)

Within the realm of individual differences, the findings of this particular research study can help set the stage for providing specific guidelines for introducing a deep approach to learning to learners routinely relying on surface approaches. In this regard it addresses the critical need for expanding the less able learner's repertoire of learning strategies, described by McKeachie (1988) in the following terms:

> The last one and a half decades have been marked by increasing public concern about the improvement of education, and particularly the education of those who, for one reason or another, enter the higher levels of education with abilities and strategies that handicap them in achieving success. In many such cases, one of the problems is that neither home backgrounds nor schools have helped young adults become aware of alternative ways of approaching learning situations. . . . Seldom is any explicit attention given to helping students become aware that they have a choice in types of learning strategies that may be employed. (p. 5)

Learning strategies successful in eliciting deep approaches are of special interest (McKeachie, 1988; Ramsden, 1985), as they foster meaningful learning outcomes, a result highly relevant to the purported goals of our educational system.

This study will specifically contribute to the existing research on cognitive mapping as it applies to the problem of knowledge acquisition from text. By presenting a new focus on the activity, namely on the process of generating links between ideas, we are able to investigate the effectiveness of a shortened procedural routine. In terms of practical application, a strategy which is simpler to learn and apply has greater appeal for students and teachers alike, and thus has a greater chance for more widespread adoption.

The study will further add to both the cognitive mapping research and the instructional design research in relation to its use of a qualitative measure of learning outcomes. Results of studies investigating effectiveness of cognitive mapping strategies, like those of other learning strategies, suffer from some confusion in interpretation arising from inconsistencies in the types of measures used. Many studies fail to distinguish meaningful from rote learning, a fact which is reflected in the criterion tests that are applied (Ausubel, 1978; Kember, 1991).

In assessing the current status of research in educational technology, Reigeluth (1989) has asserted that both learning theorists and instructional theorists have largely ignored learning characterized by understanding, and as they have only recently begun turning their attention to this type of learning, very little has been generated in terms of validated prescriptions for facilitating understanding. We see this study, in its focus on promoting meaningful learning, as addressing this need and as contributing to the prescriptive knowledge base of the field.

CHAPTER TWO

Review of the Literature:

Approaches to Learning and Cognitive Mapping

Introduction

This chapter will relate the review of the literature to the main variables of interest in the study; the relevant studies on learning approaches and cognitive mapping will be reviewed to provide a conceptual analysis for the research undertaken. At the conclusion of this review, the theoretical hypotheses describing the relationship between the variables at a concept level will be presented, along with the theoretical definitions of relevant terms. Operational hypotheses and definitions will be presented subsequently in Chapter Three, "Methods."

Approaches to Learning

Deep and surface distinction. In one of his influential contributions to the research literature, Ausubel (1963) contrasted "meaningful learning" with "rote learning" to describe two different processes applied by learners in acquiring knowledge. Meaningful learning, described as the process of establishing non-arbitrary relationships among concepts, is compared to rote learning, defined as learning concepts in an arbitrary, verbatim, and non-substantive way (p. 24).

The two different processes described by Ausubel (1963) represent a basic source of individual differences in the performance of a learning task that can be referred to as differences in learning approach. The last twenty years have generated a considerable amount of research in this area exploring individual differences in student learning, the main objectives of which have been to categorize student approaches to learning and to develop reliable measures of these approaches (Newstead, 1992).

Classifications representing dichotomous constructs similar to Ausubel's original categorizations of learning, but with different operationalized definitions, have been described by a number of researchers: Wittrock (1974) used the terms *generative* and *reproductive processing*; Marton (1975) made reference to *deep* and *surface approaches*; Pask (1976) referred to *comprehension* and *operation learning*; Biggs (1978) first contrasted the terms *internalising* and *utilising*, then later referred to *deep* and *surface* approaches (1987); Merrill differentiated *remember paraphrased* from *remember verbatim* (Merrill, Reigeluth, & Faust, 1979); Ramsden and Entwistle (1981) distinguished between *meaning* and *reproducing* approaches; Schmeck (1983) used the terms *deep* and *elaborative processing* in contrast to *fact retention*; Thomas and Bain (1984) distinguished *transformational* from *reproductive learning*.

A commonality exists in such types of descriptions (Biggs, 1987; Christensen et al., 1991; Ford, 1981; Kember

& Gow, 1989; Schmeck, 1983; Schmeck, 1988a), with the terms *surface* and *deep* most widely used to express two basic, qualitatively different approaches to learning, reflecting the terminology generated by Marton (1975) and Marton and Säljo (1976) in their early Gothenburg research.

The Gothenburg studies were critical in empirically establishing qualitative differences in how students handled learning tasks (Laurillard, 1984). Based on students' self-descriptions of their study processes, Marton (1975) described subjects using a deep approach in a reading task as (a) concentrating on the meaning of the discourse, and (b) actively making connections within the text. For example, he reported that, in describing their own behavior, these individuals made comments such as "I thought about the point of it" and "I went back to find the connections" (pp. 128-129).

Conversely, subjects using a surface approach were characterized as (a) concentrating on the surface aspects of the discourse and the task at hand, and (b) displaying a passive approach by not making associations within the text. In describing their own behavior, these subjects made the following types of comments: "I didn't think about what I was reading" and "I just read straight through without looking back at anything" (p. 129).

Marton (1976) described surface level processing in terms of the student being concerned with reproducing the *signs* of learning, that is, the words used in the text In terms of learning outcomes, the use of a surface approach would thus to a literal reproduction of strings of words from a text. Svensson (1976) also referred to this phenomenon, describing it as an "atomistic approach", wherein the learner focuses on "the sequence of text . . .[on] details and . . .[has] a lack of orientation towards the message as a whole" (p. 93). According to Schmeck (1988c), this approach "does not include perception of the holistic structure of information but instead atomizes it into disconnected bits and pieces that are memorized through repetition" (p. 321).

In contrast, students using a deep approach are concerned with learning "what is signified", that is. the meaning of the text. According to Marton (1988) and Kirby (1988), the intent of students using a deep approach is to extract meaning from words in order to uncover the author's intended meaning. Svensson (1976) described this as a "holistic approach" characterized by the learner's "direction toward understanding the text as a whole" (p. 93). A deep approach includes perception of a holistic organization which is reflected in the learning outcome. This necessitates a sensitivity to structure and thus to relations among topics: "In order to establish a structure, that is, relations among components, these components have to be seen in relation to each other, they have to be seen as parts of the same whole" (Marton, 1988, p. 77).

This deep-surface distinction explored by Marton (1975, 1976) and then further investigated in the subsequent Gothenburg studies (e.g., Marton & Säljö, 1976, 1984; Säljö, 1982; Svensson, 1976, 1984) and by others (e.g., Laurillard, 1979, 1984b) appears to relate to most learning tasks. Typically, nearly all learners could be classified as having taken a deep or surface approach. In Marton's (1975) words, "it would appear that a decisive factor in non-verbatim learning, both in experimental settings and in everyday work, is the learner's approach to learning" (p. 133).

The Gothenburg research reflects a phenomenographical approach, which derives descriptive concepts from students' descriptions of their own study processes, and has an experiential rather than theoretical grounding. Similar frameworks for describing learning processes have also been derived from other perspectives, including that of cognitive psychology. Schmeck, Ribich, and Ramanaiah (1977), for example, identified significant learning processes from the existing experimental research on human learning and translated them into study behaviours. Some researchers, however, claim such extrapolation to be a complicated issue, as the theoretical constructs resulting from the findings are difficult to operationalize; the results thus describe "only the mental operations used in tackling narrowly defined experimental tasks" (Entwistle & Waterston, 1988, p. 264).

For the purposes of the current study, we find the qualitative analyses of student self-report descriptions of deep and surface approaches to learning, based on the Gothenburg studies, a relevant starting point in deriving concepts describing effective study processes. Henderson (1984) has claimed that if we accept the importance of learning approaches, then "a crucial issue is whether one can influence learners' approaches to learning" (p. 43). If we can define effective learners as those who are able to adopt a deep approach to a learning task, and if we are able to determine the strategies which characterize this approach, then our interest is in helping other learners to apply these strategies.

Marton (1988) referred to the differences in learning approach as differences in the "act" or "the how" of learning. In this study we are interested in operationalizing "the how" of a deep approach to learning, which we can specifically describe in terms of the ability to build internal connections while reading a passage of text.

Components of learning approach. An approach to learning can be described as being comprised of both motive, or intention, and strategy (Biggs, 1987a, 1990; Entwistle, 1988; Schmeck, 1988a). The learner's motives are considered to predispose him or her to adopt a distinct study strategy. Qualitative data from student interviews have consistently provided evidence of the critical role of student intention in approaching a learning task (Entwistle, 1988). In terms of the strategy component of learning approach, we are referring specifically to the learner's deployment of a learning strategy characterized by either meaningful interaction with content or rote memorization.

A deep approach can be regarded as a combination of the intention to achieve an understanding of material and a strategy which involves a critical interaction with the content resulting in meaningful links being made. A surface approach, on the other hand, is characterized by the less personal intent of fulfilling task requirements through reproducing material and a strategy based on rote memorization.

To gain additional insight on how learners establish approaches to learning, certain researchers have studied the link between an individual's learning approach and his or her conception of learning (e.g., Biggs, 1990; Gibbs, 1981; Marton & Säljö, 1984; Säljö, 1979; Van Rossum & Schenk, 1984). Findings from these studies indicate that students have different ways of conceptualizing the process of learning new knowledge, reflecting either quantitative or qualitative interpretations.

Students who adopt a deep approach tend to hold a *qualitative* conception of learning, that is, they view learning as the abstraction of meaning or as an interpretative process that helps in building a personal philosophy. Students using a surface approach tend to believe that learning is the acquisition of facts and is an outcome of memorization. Viewing learning in such terms reflects a *quantitative* view of learning. One's approach to learning may well begin with how one defines learning (Schmeck, 1988c). Linking students' conception of learning to their predisposition to adopt a certain learning approach would provide support for the notion of consistency of learning approach, an issue of importance in this research.

Consistency in approach. The consistency within the learner of an approach to learning across situations is not a simple issue to address and, as such, has not yet been totally resolved (Kember & Gow, 1989). Related questions that serve to highlight the importance of the issue include those posed by Ramsden (1988):

> To what extent are the ways in which students learn determined by individual differences in learning style and to what extent by students' responses to environmental demands? Are approaches to learning stable attributes of students, or are they alterable? (p. 174)

Studies by researchers such as Entwistle, Hanley, and Hounsell (1979) and Biggs (1978, 1979, 1987a) provide evidence that inventories (self-report questionnaires) can be used to categorise learners on their characteristic orientations to studying in ways that imply a consistency in approach (Ramsden, 1988). (Assessment of learning approaches will be discussed in a later section.)

A number of studies (e.g., Entwistle & Ramsden, 1983; Säljö, 1981; Svensson, 1976) provide evidence, based on both quantitative and qualitative data, supporting the existence of consistency in learning approach. These studies have shown that stable tendencies to use specific strategies are associated with specific measures of learning outcome. Other studies also provide evidence of such stability across learning tasks and time (Biggs, 1990; Entwistle & Ramsden, 1983; Laurillard, 1984b; Säljö, 1981; Svensson, 1977; Thomas & Bain, 1982).

Finding that the majority of students could be classified as adopting either a deep or a surface approach to most tasks, Entwistle (1988) has referred to this regularity in approach as the student's "orientation". According to Schmeck (1988c), this orientation "reflects a habitual, cross-situational preference for one of the approaches to learning, and such a preference is determined by the person's motives and cognitive style" (p. 329).

Biggs (1976, 1978, 1987a, 1988a) has also attributed this consistency to the stability of personal characteristics, such as tolerance for ambiguity, dogmatism, as well as aspects of cognitive style, such as cognitive complexity and convergence-divergence, all of which are considered to influence perception of situations, such as learning tasks in school.

Cognitive style is thought by some researchers to be the most stable of personality characteristics, with motives towards schoolwork also considered to be relatively stable (Schmeck, 1988c). Cognitive styles in general can be described as tendencies or preferences to respond to intellectual tasks and problems in a particular fashion (Biehler & Snowman, 1993), and have been described in terms of a variety of different dimensions (e.g., Guilford, 1967; Kagan, 1964; and Messick, 1976; 1984).

In more closely examining the notion of cognitive styles as a trait characteristic, we refer to Kogan's (1971) definition of cognitive styles as:

> Individual variations in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming and utilizing information. . . .[Unlike abilities which concern level of skill] cognitive style gives greater weight to the manner and form of cognition. (p. 244)

In a similar vein, defining cognitive styles as "information processing regularities that develop in congenial ways around underlying personality trends", Messick (1982, p. 4) identifies 19 different cognitive styles that have been studied, including the most widely known, namely, field dependence-independence, cognitive complexity-simplicity, reflectivity-impulsivity, risk-taking, and convergence-divergence.

The use of cognitive styles as a relevant construct represents a controversial issue, however, as the differences between traits, preferences, and abilities are subject to numerous interpretations (Das, 1988). Recent attempts to re-conceptualize this area of study (e.g., Messick, 1984), do not resolve what are considered by some researchers to be basic weaknesses in measures used to assess cognitive styles. Tiedemann (1989), for example, criticizes measures of cognitive style, even the most well-publicized, as lacking consistent convergent and discriminant validity, and thus calls into question the value and utility of most cognitive style research.

Despite the mentioned criticisms, and although we must exercise care in the use of related theoretical constructs, we may still refer to those studies which appear to substantiate the existence of certain style-like individual differences that may help to explain consistencies in learning behavior.

Pask (1976), for example, found stylistic differences in the way individuals try to understand a body of information. In examining patterns of response to a learning task, Pask found evidence that "serialists" proceed to search for specific data in a step-by-step fashion, while "holists" are apt to "test a large predicate or relational hypothesis" and "scan large amounts of data searching for patterns and relations" (Pask, 1988).

On the basis of his review of the body of cognitive styles research, Schmeck (1988c) has suggested that "all cognitive styles can be encompassed by one broad, inclusive dimension of individual difference labeled 'global versus analytic'" (p. 327). He also suggested that people with a global style can be described as having organizational schemes that "involve more random or multiple accessibility of components, allowing numerous and various associations between coded experiences" (p. 327), while those with an analytic style have linear and sequential organizational schemes.

Marton (1988) also interpreted the evidence of deep and surface approaches as reflecting stylistic differences, namely, the atomistic, sequential tendencies demonstrated in surface approaches and the holistic, hierarchical tendencies apparent in deep approaches. On the basis of reviewing the relevant research, Schmeck (1988c) has suggested that analytic style and surface approach are related, as are global style and deep approach (p. 329).

The link between learning approach and cognitive style may be important to note here. In critically assessing the notion of cognitive styles as an aptitude construct, Corno and Snow (1986) have recommended that:

> Cognitive styles are best placed within a zone of ability-personality overlap when their definition follows Messick's emphasis on an individual's *typical propensity* for a certain manner of work in given

situations. Typical propensity is hypothesized to differ from but be constrained by one's enabling competence (intellectual ability) and enduring disposition (personality). (pp. 617-618)

The notion of typical propensity represents an explanation for consistency in learning approach that appears to be in agreement with the descriptions of learning approach presented here. Such consistency has been noted by Ramsden (1988) as being "entirely in accord with common sense" as "it is not surprising that individual students develop habitual ways of approaching study tasks" (p. 175).

It is relevant to note here the connection between the notions of cognitive style and learning style, terms which have often been used interchangeably. According to Schmeck (1988c), for example, one may regard learning styles as simply an application of cognitive style to a learning task. Curry (1990b) has referred to the "bewildering confusion of definitions surrounding learning style conceptualizations", but has also noted a "consensus emerging in the literature towards using the word 'style' to refer to information processing routines which function in a trait-like manner at the personality level" (p. 2). We would like to emphasize the focus on "trait-like manner" to support the notion of consistency in learning processes within the individual.

The role of context. We reiterate one of the questions posed by Ramsden (1988), "To what extent are the ways in which students learn determined by individual differences in learning style and to what extent by students' responses to environmental demands" (p. 174)? In reviewing the related research, we see that the notion of consistency in learning approach does not preclude some variability in approach across situations.

We need to first note, however, that the body of research studying contextual variables suffers from a lack of agreement in the definition of context, thus requiring some caution in drawing conclusions. What is meant by context requires definition in terms of both its theoretical framework and its operationalization. In commenting on the importance of studying contextual variables in general, Meyer, Parsons, and Dunne (1990) have cautioned that while there is a need to address contextual variables linking approaches and outcomes, and that while there is a theoretical structure for conceptualizing the learning process and outcomes, there has been no "theoretically robust interpretation of learning context or, indeed, an adequate conceptualisation of how it is perceived by individual students" (p. 68).

Despite this gap, in reviewing the research we do see evidence supporting the importance of contextual variables in influencing learning approach. In examining the effects of assessment measures, Thomas and Bain (1984) found that students were more likely to use surface strategies to prepare for multiple choice or short-answer tests and to use deep strategies with open-ended assignments. Adams (1964) and Biggs (1973) have likewise documented the tendency of certain forms of assessment, namely multiple choice tests, to generate surface approaches. Entwistle (1987, 1988) has noted that the use of factual questions, such as multiple-choice type questions, results in students adopting a surface approach. Entwistle & Kozeki (1985) found that the tendency for 16-year-olds in Britain to adopt surface approaches and that of Hungarian pupils of the same age to utilize deep approaches could be attributed to the nature of the external testing process.

In interviewing university students, Entwistle and Ramsden (1983) had also found that type of assessment influenced the students' approach to learning in specific tasks. In addition, they found that the quality of teaching and teaching style also influenced students in their approach to learning; the instructor's commitment to teaching and relationship with students were the most important factors in encouraging a deep approach. Other contextual factors found to affect approach included perception of a heavy workload, which was related to a reproducing or surface orientation. Perception of context is a key variable, according to Entwistle (1987), since a student's perception of the academic environment, appears to be a more direct influence on learning than the actual environment itself.

Laurillard (1984b) has suggested that the perception of task requirements helps to determine choice of learning approach. In a 1979 study investigating the applicability of learning approach descriptions to university students taking science and engineering courses, Laurillard found that 19 out of the 31 students in the study demonstrated evidence of both surface and deep approaches. Key to the choice of learning approach, according to Laurillard (1984b), is the student's perception of the learning task, which depends on "its form and content, on its relation to other tasks, on the student's previous experience, on the student's perception of the teacher who marked it and of how it will be assessed" (p. 135).

A study of contextual and personological factors influencing learning approach, conducted by Watkins and Hattie (1981), showed that both of these factors were important in the choice of approach. Biggs (1989) has likewise noted that learning approach is a reflection of the interaction between the teaching context and the student's present motivation.

Some critics have regarded the evidence of consistency in learning approach and that of contextual dependence as being contradictory. Ramsden (1984), however, has provided one explanation as to how approaches to learning can be regarded as both stable and contextually dependent:

> Learning is a function of the individual's engagement with the learning context. The pattern of engagement is incompletely determined by the context's characteristics, as perceived by the student - incompletely because many other variables, including luck and determination, influence it. The student's perceptions are partly determined by previous experiences (in which the individual will have developed characteristic modes of thinking and perceiving as responses to educational tasks) and partly by the characteristics of the context. As long as experiences and contexts differ, as in "natural" learning settings, and as long as students strive to adapt to the learning environment, an observer will note elements both of consistency (differences between individuals on different tasks) and of variability (differences within an individual between task contexts). It is fruitless to ask which side of the consistency-variability argument is right; they are looking at the phenomenom from different points of view. They are complementary rather than conflicting explanations. (p. 177)

In sum, we thus see that there is evidence supporting the notion of flexibility of learning approach with regard to individual activities as well as evidence supporting consistency across tasks.

Context and individual differences. In examining more closely the research on contextual variables, we find that individual differences in learning approach appear to mediate the influence of context. Saljo (1975), for example, demonstrated that most students could be induced to adopt surface approaches if the context called for it. A far more limited number of students, however, could be induced to adopt a deep approach. In Marton and Säljö's (1976) study, which examined the effect of manipulating the nature of the assessment questions asked, it was found that: (a) students who were asked surface level questions gave surface responses, and (b) students who were asked deep level questions gave either a deep response or a surface response.

In interpreting such results, Ramsden (1988) and Biggs (1990) have claimed that a student with a quantitative view of learning or reproductive orientation (i.e., a learner who routinely adopts a surface approach) is likely to adopt a surface approach in any situation. Meanwhile students with a qualitative view or meaning orientation (i.e., students who routinely adopt a deep approach) may exercise choice of approach to the learning task and are inluenced by context.

Kember and Gow (1989) have similarly accounted for individual differences:

> Contextual variables influence students towards surface strategies for specific tasks. In the model we

> present, this is the normal strategy for students with a surface predisposition. Students with a deep predisposition will readily be able to adopt a surface strategy if they sense it is required, or feel pressured in that direction. (p. 272)

In reviewing the studies which investigate the relationship between learning approach, context, and outcome, it becomes evident that the results tend to confirm that students characterized by a deep approach are influenced by context and appear to have a choice of strategy in producing a learning outcome, while those characterized by a surface approach do not appear to have a choice in responding to context. Laurillard's (1984b) suggestion that the "operational outcome" of a student's perception of context "is an intention either to understand or to memorize, and thereby to use either a deep or surface approach" (p. 135) may be applicable only to students who can adopt a deep approach.

It is relevant to note that the individual's own use of learning strategies, according to Rigney (1978), may not be apparent to certain learners: "It seems likely, in fact, that many students fall into ways of learning - possibly as a consequence of haphazard reinforcement of which they are not aware" (p. 167). Entwistle has suggested that students' experience in school in general encourages rote rather than meaningful learning (1987), as Ausubel (1978) had previously similarly noted:

> One reason why pupils commonly develop a rote learning set in relation to potentially meaningful subject matter is because they learn from sad experience that substantively correct answers lacking in verbatim correspondence to what they have been taught receive no credit whatsoever from teachers. Another reason is that because of a generally high level of anxiety . . . they lack confidence in their ability to learn meaningfully, and hence perceive no alternative to panic apart from rote learning. (p. 43)

Harri-Augstein and Thomas (1991), in describing a "robot-like lack of awareness" in certain learners which gives rise to task-bound "learning conversations" "largely ritualized" (pp. 96-97), may well be describing learners who characteristically utilize a surface approach. Students employing deep approaches, evidently demonstrating greater "awareness", appear to have greater choice in responding to context. Biggs (1985) has maintained that the extent to which learners consciously select strategies which are appropriate to the particular task demands is a reflection of their capacity for meta-learning.

Assessment of learning approaches. As noted earlier, a key goal of research in the area of learning approaches has been not only to characterize different approaches, but to develop reliable tools for their measurement. Many of the assessment instruments that have been developed have been primarily used as research tools to assist in the study of student learning (Newstead, 1992).

Measurement is an important issue in terms of both research in learning approach issues and practical applications. Appropriate tools are required for assessment purposes leading to a variety of practical applications. Biggs (1987a) has discussed the value of assessment for instructional decision making, both formal, that is, for the development of curriculum objectives and the use of instructional and evaluation processes, and informal, that is, to "modify the interaction between the teacher and particular student" (pp. 106-107). Assessment measures, according to Biggs, can also be used to identify cases for referral to a counsellor: (a) to help individual students study more effectively, and (b) to assist in vocational decision-making and career counselling (p. 107).

At least two main types of perspectives on assessment can be identified (Biggs, 1979; Watkins & Hattie, 1981): (a) a qualitative approach based on interview data from observational/experimental studies of students engaged in learning tasks (Marton, 1976; Marton & Säljö, 1976; Svensson, 1977), and (b) a quantitative approach based on large scale studies in which learners are classified according to characteristics assessed based on self-report questionnaires (e.g., Biggs, 1987a; Entwistle & Wilson, 1977; Schmeck et al., 1977).

The first approach, which characterizes the Gothenburg studies, involves in-depth one-on-one interviews wherein students are asked to describe how they handled a given learning task and how it appeared to them (Marton & Sàljò, 1984). The investigators then interpret the data derived from the interviews for classification purposes. The second approach involves the student answering a questionnaire on how they learn. A basic assumption underlying the development of such self-report questionnaires is that learners have relatively stable motives and strategies for learning, and that these arise from both personal characteristics and exposure to specific contextual requirements (as discussed in a previous section).

The two approaches to this research can be regarded as complementary (Entwistle & Hounsell, 1979), each offering specific advantages in contributing to knowledge of the learning process. A qualitative approach based on small samples of subjects providing introspective accounts of how they actually learn represents a rich source of data. There are, however, problems with regard to subjectivity in assessment and lack of reliability of methods. In terms of practicality, the lengthiness of the interview process serves to impede the use of such an approach for applications within schools. A quantitative approach has fewer constraints in its use and yields empirically verifiable results, but on a restricted range of items (Watkins, 1983; Watkins & Hattie, 1983). The ease of administering and scoring questionnaires strongly contributes to the acceptance of this approach in applied settings.

The issue of whether questionnaires can be used to assess individual differences in learning, namely, surface and deep approaches to learning, has been directly addressed by several researchers who have develope: such instruments, most notably Entwistle (Entwistle et al., 1979; Entwistle & Ramsden, 1983; Entwistle & Wilson, 1977), Schmeck et al. (1977), and Biggs (1979, 1987a). The analyses conducted by Entwistle and Ramsden (1983) of their assessment instrument, i.e., Approaches to Studying Inventory (ASI), and the work of Biggs (1978, 1979, 1987a) in developing two instruments, i.e., the Study Processes Questionnaire (SPQ) (designed for university students) and the Learning Processes Questionnaire (LPQ) (designed for secondary students), support the notion of stability and replicability of deep and surface approaches or orientations to learning (Ramsden & Entwistle, 1981). These instruments are closely aligned with the surface/deep distinctions outlined in the Gothenburg research. As discussed previously, the instrument developed by Schmeck et al. (1977), i.e., the Inventory of Learning Processes (ILP), was based on a framework derived from the perspective of cognitive psychology, whereby significant learning processes from the existing experimental research on human learning were translated into learning behaviors.

There appears to be some consistency across instruments in assessing learning approaches. In a study, for example, comparing instruments derived from the two different theoretical perspectives discussed above, namely, Schmeck's Inventory of Learning Processes (ILP) and Entwistle's Approaches to Studying Inventory (ASI), "a remarkably close" coincidence between scales was demonstrated (Entwistle & Waterston, 1988). In this study, Entwistle and Waterston administered questions from the two inventories to a sample of 218 university students, then calculated correlations between subscales from both instruments, finding a number to be statistically significant. For example, a .50 correlation was found between Surface Approach (Entwistle subscale) and Surface Processing (Schmeck subscale); a correlation of .64 was reported between Deep Approach (Entwistle subscale) and Elaborative Processing (Schmeck subscale). In undertaking a factor analysis of the combined inventories, the researchers found four dimensions (i.e., deep/elaborative, surface, organised, and strategic/competitive) to be "composed of a spread of items which link, in an intelligible way, intention and motivation with distinctive cognitive processes" (p. 264).

There is evidence, however, that the application of existing assessment measures have some problems related to validity and reliability. Studies of individual measures have provided questionable results. Newstead (1992), for example, found some weaknesses when examining the reliability and validity of two instruments measuring individual differences in learning, namely, a shortened version of Entwistle and Ramsden's (1983) Approaches to Studying Inventory (ASI) and Kolb's (1973) Learning Style Inventory (LSI). The reliability of certain scales in the short form of the ASI were found to be low; reliability for the scale measuring reproducing orientation, for example, was .44. Although a factor analysis revealed support for the predicted factor structure of the ASI, there were some problems with particular items. In examining the reliability of the LSI, Newstead found the reliabilities of all four of its scales (concrete experience, reflective observation, abstract conceptualization, and active experimentation) to be low, ranging from .30 to .54. Furthermore, a factor analysis demonstrated little support for the predicted factors.

In surveying the body of research in cognitive and learning styles as a whole, Curry (1990b, 1991) has noted that these weaknesses are in fact pervasive and represent an area of serious ongoing concern. According to Snider (1990), a number of well-known and frequently used instruments, for example, the Learning Style Inventory (Dunn, Dunn, & Price, 1985) and the Reading Style Inventory (Carbo, 1983), have questionable value because of inadequate reliability and validity (Stahl, 1988). Related problems have been noted in the assessment of cognitive style. In reviewing measures of cognitive styles, Tiedemann (1989), for example, has criticized cognitive style research in its reliance on measures lacking consistent convergent and discriminant validity, and has, in fact, concluded that: "There is insufficent empirical evidence for any construct of a cognitive style in the sense of a bi-polar, value-differentiated and pervasive preference dimension" (p. 272).

Despite the outlined problems, we were able to choose appropriate instrumentation for the purposes of our study on the basis of recommendations made by Curry (1990). Our main interest here in assessing individual differences is to enable us to identify and address more specifically the need of less skilled learners to improve their ability to learn in a meaningful fashion. We are interested in doing so within the context of practical application within a high school setting. We have chosen Biggs' LPQ as the means of differentiating students who rely on surface approaches, from those students who routinely rely on deep approaches. In Chapter Three, "Method," the section on "Instrumentation" will provide more detail on the LPQ and the method used in this research.

Changing approaches to learning. In this section we are looking at the problem of how to alter learning approaches, specifically the approach of the surface learner. As discussed previously, there is evidence that students using deep approaches can be influenced to adopt surface strategies if the context calls for it. In the case of students relying on surface approaches, however, the transition to a deep approach appears to be difficult.

In Marton and Säljö's (1976) study, two groups of students were asked to read a passage of text containing questions; one group was asked questions requiring a surface response, while the other group was asked questions designed to elicit a deep response. In the latter group, it was found that one set of learners did not adopt a deep approach although the situation called for it, and it has been suggested that this group of students could be categorized as having a "surface predisposition" (Kember & Gow, 1989). This suggests that context (e.g., the presentation of tasks requiring a deep approach), although influential in the choice of approach taken by learners who adopt deep approaches, may not elicit a deep approach from learners routinely using surface approaches.

Säljo (1979) contended that learners who were responsive to context "realise that there are, for instance, alternative strategies or approaches which may be useful or suitable in various situations depending on, for example, time available, interest, demands of teachers and anticipated tests" (p. 446). In commenting on Säljo's position, Richardson (1983) has stated that it "implies that the deep and surface approaches to learning are hierarchically related, such that access to the former necessarily implies access to the latter, but not vice versa" (p. 318). Richardson also has questioned "whether this proposition is empirically testable" (p. 318). In discussing the difficulty of influencing surface learners to adopt deep strategies, Kember and Gow (1989) have highlighted the role of conceptions of learning, noting that "many of the students with a surface disposition will have a conception of learning incompatible with a deep approach" (p. 273).

Kember and Gow (1989) have outlined three broad approaches to re-orienting students with surface approaches to acquire a deep approach: "(1) teaching skills appropriate to a deep approach, (2) reorienting students' conceptions of knowledge, and (3) consistently presenting deep level study tasks" (p. 264).

In teaching skills considered to facilitate learning with understanding, the assumption is made that surface students lack these skills. The idea of teaching surface students strategies utilized by deep students appears to be common sense (Laurillard, 1984b). Traditionally the approach taken in teaching study skills has been to recommend a prescribed method for specific tasks, such as the SQ3R (survey-question-read-recite-review) approach to reading (Robinson, 1970). According to Kember and Gow (1989), the criticisms directed at the prescriptive approach have been addressed in the development of other approaches which do not assume that there is a single correct technique for a learning task. The "supermarket approach", for example, provides learners with a range of techniques to choose from, while the "context-related approach" provides discipline-related techniques. The "metacognitive approach", on the other hand, helps learners develop "awareness of their own strategies which enable them to select and guide the processes involved in defining and solving problems" (Kember & Gow, p. 274).

There is little conclusive evidence of the effectiveness of any of these approaches to teaching study skills, although research by Biggs and Rihn (1984) has shown the possibility of successfully intervening to "induce a deep approach in surface processors" among university students (p. 282). The intervention, based on a metacognitive approach, consisted of a 9-week course in "Effective Learning Skills" and included such topics as time management, goal setting, understanding and remembering what is read, and note taking. Using pre- and post-SPQ (Study Process Questionnaire) scores, the researchers found a significant drop in surface approach after the course and a significant increase in deep approach. On the basis of these results they suggested that adaptive strategies to learning can indeed be learned.

The second major approach presented by Kember and Gow (1989) to helping students with surface approaches acquire a deep approach is to re-orient students' conceptions of knowledge. This approach stems from the work by Säljö (1979) discussed earlier, in which differences were found in quantitative versus qualitative conceptions. It is based on recommendations made by Gibbs (1981) to help students learn to learn by helping them "shift the focus of their thinking from seeing knowledge as discrete items of information which must be memorised, to one where they attain through understanding and through a global perspective of knowledge and its interrelatedness" (p. 279). Again, because of the paucity of research in this area, empirical support for this approach is lacking, with the exception of one study (Marton & Ramsden, 1987), where there was some evidence of a learning-to-learn program at the university level improving students' performance.

The third approach discussed by Kember and Gow (1989) to changing the surface learner's approach to a deep one involves changing the learning environment itself through the use of methods like the following: "(a) use of a preliminary organiser (Melton, 1984), (b) activity-based learning (Laurillard, 1984a), (c) learning through case studies (Crooks, 1984), and (d) project-based learning (Morgan, 1984)" (p. 33). Fundamental to changing the learning environment and methods used appears to be the necessity to change the teachers' approach to teaching.

This is a complex need involving issues such as helping teachers resolve the discrepancy between "espoused theories" and "theories-in-use" (Bowden, 1988), that is, to operationalize their theories and be able to apply them in the classroom, and may involve a change in the teache ' conception of teaching. Again research on the effectiveness of this approach is scarce, although the results of two studies (Coles, 1985; Newble & Clarke, 1987) (as discussed in Kember & Gow, 1989) indicate that different learning environments can indeed result in different approaches to learning.

Ramsden and Entwistle (1981) have maintained that the objective of research in student approaches to learning is "to identify ways in which students' approaches to learning may be modified either through appropriate study skills courses, or through the course organisation, assessment and teaching methods of departments" (p. 380). In their 1981 study, Ramsden and Entwistle were able to conclude on the basis of correlational analyses investigating the relationship between students' course perceptions of academic departments and their approaches to learning, that although causality could not be established, it appeared that changes in teaching practices are likely to shift students from surface to deep approaches to learning. These changes in teaching practice reflect critical contextual variables discussed previously, such as evaluation practices.

The chosen focus in the current study is the teaching of skills appropriate to a deep approach, as described in the first methodology described by Kember and Gow (1989) above. The assumption, of course, is that the surface learner does not have the skills deployed by deep learners when engaged in meaningful learning. Our task then is to identify a way in which the surface learner's approach to learning could be modified, as suggested by Ramsden and Entwistle (1981), namely, by identifying a learning strategy that reflects the strategies inherent in a deep approach and that could be taught to surface learners. This issue thus forms the basis for the next section of this literature review.

Cognitive Mapping

Building a conceptual framework for cognitive mapping. Internal mental processes and knowledge representations have been a central focus in cognitive research, and have been approached from a variety of perspectives for purposes of study. Central to an understanding of current notions of internal knowledge representation is the concept of semantic memory. Tulving (1972) distinguished between episodic and semantic memory as follows:

> Episodic memory receives and stores information about temporally dated episodes or events, and temporal-spatial relations among thes events. Semantic memory is the memory necessary for the use of language. It is a mental thesaurus, organized knowledge a person possesses about words and other verbal symbols, their meaning and referents, about relations among them, and about rules, formulas, and algorithms for the

manipulation of these symbols, concepts, and relations. (pp. 385-386)

This distinction has served to guide much of the research in the area (Holley & Dansereau, 1984b). Schema theory, based on the premise that we process information in accord with internal knowledge structures, evolved as a result of interest in semantic memory structures. As described by Rumelhart and Ortony (1977), a schema describes the organization of information in human memory and contains "the network of interrelations that is believed to generally hold among the constituents of the concept in question" (p. 101).

The introduction of the notion of *schema* as a means of describing internal knowledge structures has been attributed to the psychologist Bartlett (1932), who studied the effect of preexisting knowledge, that is, text schema, on the reader's understanding of a passage of text, and was one of the first to propose a functional model of semantic memory. The philosophical origins of the idea of internal constructs, however, can be traced back to Kant. Others who have contributed to the evolution of the idea include the German structuralists such as Titchener (1910), the Gestalt psychologists (e.g., Koffka, 1935; Wertheimer, 1945), Piaget (Inhelder & Piaget, 1958), and Bruner (1973).

In a commonly accepted understanding of the term, a schema refers to an internalized mental structure that serves to organize knowledge (Howard, 1987; Norman, Gentner, & Stevens, 1976; Rumelhart, 1980, 1984; Rumelhart & Ortony, 1977; Schallert, 1982). Romiszowski (1986) describes schemata in terms of "conceptual structures" which "undergo continual change and growth" (p. 54). Similar concepts describing such mental representations that have emerged in recent work in cognitive science include *frames* (Minsky, 1975; Winograd, 1976) and *scripts* (Schank, 1975). Bruner (1966) and Winograd and Flores (1987) have referred to *internal representations*, while others have made reference to *mental models* (e.g., Gentner, 1983; Jih & Reeves, 1992; Johnson-Laird, 1983, Mayer, 1975; Norman, 1983).

An internal representation can be described as a stored package of knowledge which is a "relatively highly coherent area in a knowledge network" (Breuker, 1984, p. 31). This type of internal structure, reflecting the storage of knowledge or content, can be referred to as *data schemata* or *state schemata*, while a second type of internal structure, *process schemata* represent procedures for processing and organizing information (West et al., 1991).

West et al. (1991) have summarized the functions of schemata as follows:

1. Schemata aid perception.

   A. Facilitate selective allocation of attention

   B. Perception is schematically constructed.

2. Schemata aid learning, comprehension, and recall.

A. Provide ideational scaffolding for the assimilation of events, text information.

B. Allow inferential elaboration.

C. Allow orderly and consistent search oi memory.

D. Aid editing, abstracting and summarizing.

E. Permit inferential reconstruction. (p. 10)

Holley and Dansereau (1984a) have noted that schema theory in itself "does not have the precision necessary for providing a basis for detailed predictions in educational settings or for development of explicit learner strategies for acquiring schemata" (p. 4). The latter point is relevant to our concern in this study, as we seek to identify a learning strategy that would help the surface learner acquire, in effect, a schema for meaningful learning.

Representational schemes for semantic memory. In attempting to work out detailed representational schemes for semantic memory, theorists have developed various schemes, the most influential one being based on node-link structuring principles. Quillian's (1968) proposal that memory was organized as a network of concepts and relationships provided the impetus for the development of more sophisticated schemes (e.g., Winograd, 1972; Rumelhart, Lindsay, & Norman, 1977).

Other relevant representational schemes include those based on propositional structures (e.g., Anderson & Bower, 1973; Kintsch & van Dijk, 1978), wherein relationships are represented as grammatical propositions and have been used in models of text comprehension (e.g., Frederiksen, 1972; Kintsch, 1974; Meyer, 1975). For the purpose of analysis, a text is analyzed into propositional elements that represent components larger than a word and smaller than a clause or sentence. Holley and Dansereau (1984a) have noted the usefulness of such a model has been "in the description of the ongoing process by which a reader takes the print on the page and constructs a meaning for it piece by piece" (p. 5).

Such a process is interesting and relevant insofar it may well describe the intent of the *general* meaning-building strategy applied by a learner applying a deep approach in reading a passage of text. These models of text comprehension, however, are based on linguistic knowledge or textual structures. As such we need to be cautious in making generalizations as research in text processing has demonstrated the limitations of such approaches in explaining how knowledge is acquired from text (Denhière & Baudet, 1989). Newer approaches to the topic of text comprehension acknowledge the subjective nature of the task and focus more on the learner's interpretation of the text, as we shall discuss in a later section in this paper.

Internal processes. Models of processing associated with semantic memory intended to describe the processes involved in the use of these types of representations include Craik and Lockhart's (1972) depth of processing model. The notion that information can be processed at qualitatively different levels represented a significant contribution by Craig and Lockhart to the description of learning from verbal material.

The deepest level of processing is described as involving the construction of meaningful, semantic representations, while the shallowest level is concerned with the physical properties of the stimulus. The assumption that deeper processing results in better memory resulted in Craik and Lockhart's assertion that "materials be processed semantically and elaboratively, rather than merely being recycled via rote rehearsal" (Goetz, 1984, p. 52). Craik and Lockhart's notion of levels of processing is similar to the distinction applied by Marton to help describe the relationship between the process used by learners in reading text and the resulting level of complexity of their comprehension of the text (Marton, 1975). His focus was to study these levels of processing through the use of introspective interviews, as we discussed earlier. In looking at Biggs' work, we need to note that his inventories describe approaches that relate closely to surface- and deep-level processing (Biggs, 1987a; Biggs & Rihn, 1984).

Cognitive mapping and mental representations. Knowledge in any given domain can be described in terms of systems and subsystems of concepts meaningfully linked (Mitchell, 1984). Although conceptual relationships can be represented in different ways (Howard, 1987), demonstration of the interconnectedness of concepts is best served through relational representations, such as networks (e.g., Brueker, 1984; Harary, Norman, & Cartwright, 1965; Posner, 1978) and entailment structures (Pask, 1976, 1988).

As mentioned previously, we will refer to these externalized representations as *cognitive mapping* (Eden, Jones, & Sims, 1983). The process of graphically representing perceived relationships between concepts has been variously referred to in the literature as *concept mapping* (e.g., Deshler, 1990; Novak, 1984, 1990; Rowntree, 1979), *mind mapping* (Buzan, 1982; Wycoff, 1991), *mapping* (Buckley & Boyle, 1983), *creating pattern notes* (Fields, 1980), and *clustering* (Singer & Donlan, 1989), as well as by other terms.

The exercise of mapping ideas has various useful applications, and is especially pertinent to tasks where it is beneficial to construct a display of interrelationships in ord to convey content, as in instructional planning and curriculum development (e.g., Stewart, Van Kirk, & Rowell, 1979), and lecture preparation (Dansereau, Collins, McDonald, Holley, Garland, Diekoff, & Evans, 1979). Romiszowski (1986) has described the usefulness of "structured writing" or "mapping" techniques for preparing instructional materials. The mapping of ideas is also considered to be of value as a means of generating ideas for essay-writing, of organizing thoughts when note-taking from lectures, and of evaluating students' learning.

In terms of its specific use as a learning tool, concept mapping as a strategy for learners to schematically represent domain structures has been investigated at Cornell University (Novak & Gowin, 1984). In a study investigating learning and problem solving in science, Novak, Gowin, and Johansen (1983) found that concept mapping, in combination with a technique called Vee diagramming, was of benefit to students as young as seventh graders in promoting learning. Novak and Gowin (1984) acknowledge the derivation of these techniques from Ausubel's theory of meaningful learning, discussed earlier.

Cognitive mapping as a learning strategy. In this study we are specifically interested in strategies that students could learn that would enable them to build connections. The notion of process schemata (West et al., 1991) discussed earlier (i.e., internal structures which represent procedures for processing and organizing information) is relevant to describing the ways people learn (i.e., the mental activities performed or strategies used). We are interested in the development of such schemata in less effective learners.

These can be referred to as *cognitive strategies* or the "operations and procedures that the student may use to acquire, retain, and retrieve different kinds of knowledge and performance" (Rigney, 1978, p. 165) or as *learning* *strategies,* defined earlier as "behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process" (Weinstein & Mayer, 1986, p. 315), terms that are often used synonomously.

The strategies of specific interest in this study are those that would facilitate the building of relationships between ideas in the construction of coherent internal knowledge structures, state schemata.

Spatial learning strategies. Mapping strategies specifically applied to the understanding of text may be referred to as *spatial learning strategies* (e.g., Brueker, 1984; Holley & Dansereau, 1984a; McKeachie, 1984; West et al., 1991). These strategies require the learner to select concepts and map (on paper) their relationships, thus constructing a model of the content of the text. Spatial learning strategies, such as those to be described, encompass a variety of techniques resulting in different types of representations.

These approaches are, in general, based theoretically on research in long-term memory structure, which we discussed earlier (e.g., Quillian, 1968; Rumelhart, Lindsay, & Norman, 1972). According to Holley and Dansereau (1984a), the premise is that "learning and processing strategies will be more effective and efficient, if they encourage students to perform activities and create structures that are congruent with memory systems operations" (p. 4).

The technique of networking, as developed at Texas Christian University (Holley & Dansereau, 1984b; Holley, Dansereau, McDonald, Garland, & Collins, 1979; Long, 1976), places an emphasis on the abstraction of an overall framework for the text in the form of a network map, which requires the student to label relationships between key ideas using a set coding scheme. This process involves the identification of "hierarchies", "chains", and "clusters".

Holley et al. (1979) performed a study with undergraduate students to investigate the effects of using networking on recall of main ideas and details. Subjects were trained and given practice in the technique, then were asked to use networking in studying a passage of text. A control group was asked to use their routine study techniques in studying the same passage. Students trained in the use of networking performed significantly better than control students on the dependent measure assessing the acquisition of main ideas (i.e., the sum of scores on an essay test and a summary-oriented concept cloze test) ($p<.03$). As a point of interest, an examination of the scores (reported in percentages) reveals a difference of approximately 16 percentage points between the two groups on this measure (i.e., a mean of 63.2 for the experimental group compared to a mean of 47.2 for the control group). No difference was found in the comparison on the measure assessing acquisition of detailed knowledge (i.e., the sum of scores on a multiple-choice and a short-answer test). These scores appear to be relatively poor for both groups (i.e., a mean of 40.1 for the experimental group compared to a mean of 39.8 for the control group).

Of particular interest is the finding that differences were found in the effectiveness of the networking technique on the details measure when subjects were divided into high and low grade-point-average groups (to be discussed later in this chapter in the section, "Individual Differences in the Use of Cognitive Mapping").

Mapping as a text comprehension strategy developed at the University of Illinois (Armbruster & Anderson, 1980, 1984) requires the student to graphically depict relationships in text material in a two-dimensional diagram using a given set of relational conventions. These conventions represent seven basic relationships that may exist between two ideas, namely, "is an example of", "is a characteristic of", "is greater than or less than", "occurs before", "causes", and "is the negation of". Empirical support for this technique, as it awaits further investigation, is limited to that provided by two studies which demonstrated that mapping facilitates delayed recall of short narrative prose (Armbruster & Anderson, 1980, 1984). The techniques of mapping and networking are based on the assumption that relationships between the concepts represented in a text are cued by standard lexical and syntactic devices (Anderson & Armbruster, 1984).

Another type of spatial learning technique known as *concept structuring* (Vaughan, 1982, 1984) requires the learner to construct a diagram of the conceptual relationships he or she perceives after (or during) each of three readings of a text. The result is a graphical overview which depicts various hierarchical conceptual levels. Findings in each of three studies investigating the effectiveness of this technique, reported in Vaughan (1984), provide support for concept structuring as a strategy that enhances readers' recall of expository text.

Schematizing, another spatial learning strategy, developed at the University of Amsterdam (Camstra & van Bruggen, 1984; Mirande, 1984), requires the student to label and depict relationships between concepts using lines which are annotated to represent seven types of relationships: similarity, interaction, denial of similarity, denial of a static relation, denial of a dynamic relation, negative influence, and positive influence. The emphasis is on the representation of coordinate and subordinate relationships among ideas in the abstraction of an overall "macrostructure" of the text. Research on schematizing has been of a formative nature, with experimental support for the technique limited to one study reported in Camstra & van Bruggen (1984), demonstrating its effectiveness as a processing aid in the context of a general study skills course.

Other studies have also demonstrated the effectiveness of using various spatial techniques as learning strategies. Bean, Singer, Sorter, and Frazee (1986), for example, found that tenth-grade students who were trained in the application of a mapping strategy in conjunction with another tool, a list of options for different historical events, were better able to make predictions about the outcomes of historical events later without the options list. In another study, Boothby and Alvermann (1984) found that fourth-grade students trained in concept mapping performed better than a control group on the recall of idea units in a text-processing task when tested immediately and again after a 48-hour delay. No significant differences were found between groups when tested after a delay of one month.

Reviews of the research seem to indicate that although further studies are required to provide more comprehensive data, there is sufficient evidence that spatial learning strategies are in fact useful as learning strategies (Anderson & Armbruster, 1984; McKeachie, 1984; West et al., 1991), especially when the instructional goal involves knowledge of concepts and their relationships (Moore & Readance, 1984). As a next step in furthering research in this area, it would be important to investigate the role of individual differences. As Holley and Dansereau

(1984b) have indicated, we know "very little about the relationships between individual difference variables and training effectiveness" as applied to such strategies (p. 106). Within the context defined by the current study, it would be especially useful to determine the effectiveness of applying such strategies in improving the performance of less able learners on measures of meaningful learning.

Other comprehension strategies. Strategies, such as the spatial learning strategies described, that help an individual understand written prose can be referred to as comprising part of a larger set of strategies called *comprehension strategies* (Halpern, 1989). Comprehension strategies include both *learner-generated strategies* and other strategies which students are not likely to generate, but which are intended to act as aids in helping students discover, retain, and apply text-based information.

The results of comprehensive studies investigating the effectiveness of learner-generated comprehension strategies, aside from the spatial learning strategies already discussed, indicate that empirical evidence is generally lacking in their support (Baine, 1986). Studies such as, for example, those on notetaking (Ganske, 1981), underlining (Glynn, 1978), and the SQ3R reading strategy method (Anderson & Armbruster, 1982) have not produced any "consistent winners" (Goetz, 1984). It is important to note that there is considerable variance in assessment measures used, making it difficult to compare what was actually learned across these studies. Also, as noted by Biehler and Snowman (1993) in discussing the research on notetaking, there appears to a shortage of relevant research in this area.

One of the best known comprehension strategies not generated by the learner focuses on the use of advance organizers to facilitate meaningful learning by assisting learners to relate concepts in text (Ausubel, Novak, & Hanesian, 1978). An advance organizer is generally a brief introductory passage of text which can be described as follows (Melton, 1984):

> First, it should provide a clear and well-organized framework, or "ideational scaffolding", for the assimilation of the subsequent learning. Secondly, this ideational scaffolding should become attached to, and integrated within, the learner's existing cognitive structure, thus contributing to the development and clarification of the structure and hence to learning. (p. 61)

The effectiveness of advance organizers has been subject to considerable debate, as interpretations of results have varied. For example, on the basis of the results of their substantial review of the research, Barnes and Clawson (1975) concluded that advance organizers, as they had been used in the extant studies, do not facilitate learning, while Luiten, Ames, and Ackerson (1980) concluded on the basis of their meta-analysis that advance organizers are indeed effective in facilitating learning.

An important reason explaining the inconclusivity of results may again be the selection of the dependent measures used to assess results, as many have not been sensitive to what was actually learned in the experiment (Mayer, 1979). This is in line with Ausubel's (1978) criticism that many studies do not distinguish meaningful from rote learning. In reviewing the research which links the use of advance organizers to meaningful learning, Kember (1991) has suggested that the use of advance organizers as a means of revealing how concepts are related appears to be justified if the focus of instruction is to facilitate meaningful learning.

Our intention in this section has been to place the current research effort within the broader context of comprehension strategies. A commonality appears in the lack of conclusive evidence providing support for these strategies; yet there appears to be a growing focus on the importance of promoting meaningful learning through their use. A consensus on this focus should result in a more directed research effort.

Generative learning. In our focus on a learner-generated strategy, it is relevant here to consider Wittrock's model of generative learning, which specifies that learners comprehend information as they generate relations: (a) among the text propositions and sentences, and (b) between the text and their knowledge base and their experience (Wittrock & Alesandrini, 1990). Research based on this model has provided it with empirical support, demonstrating tnat comprehension increases when learners generate these specified relations.

In one study (Doctorow, Wittrock, & Marks, 1978) conducted with sixth graders, the generation by learners of summaries and headings for text increased reading comprehension and retention by 100%, compared with the control group. Learner generation of verbal and imaginal relations (involving the formation of a mental picture) between text and experience increased comprehension by 50% in a study conducted with fourth graders (Linden & Wittrock, 1981). Teaching metacognitive strategies for generating relations between text and their knowledge base increased the comprehension of marginally literate adults by 20% (Wittrock & Kelly, 1984).

This model of generative learning "distinctive in its emphasis on the teaching of learners to generate relations across schema, and between schema and text, as ways to increase comprehension and understanding" (Wittrock & Alesandrini, 1990, p. 490), is applicable to the current study. Meaningful learning in reading text involves the learner's active construction of relations within the text, as well as between the text and the student's experience. In our research we are interested in a strategy for generating and demonstrating relations the learner perceives in the text. Insofar as the research extant provides the generative model with empirical support, it also provides support for one of the underlying premises of the current study.

Simplifying spatial learning strategies. As we have seen, spatial learning strategies have been found to be useful as learning aids in helping students understand text. There are, however, some perceived difficulties in their application, namely the length of time required to train students in their use and to apply the strategies in completing routine school assignments (Anderson & Armbruster, 1984; McKeachie, 1984, 1988).

According to McKeachie (1988), most students require approximately 12 to 24 hours to automatize such strategies. For example, in Vaughan's (1984) research, the *Construct* procedure required 20 sessions of instruction for adolescent students, while Mirande and Camstra (as described in Mirande, 1984) used six 2-hour sessions of instruction plus 10 hours of homework in the teaching of schematizing. Dansereau et al. (1979) reported two hours of training each week for twelve weeks.

Applying spatial strategies for the purpose of studying in the completion of school assignments also requires considerable time, and Mirande (1984) has reported that students view these strategies as too time-consuming. Spatial learning strategies as applied in the mentioned research are in effect a form of discourse analysis, and as described by Schallert, Ulerick, and Tierney (1984) represent a form of "drudgery" as the exercise entails decisions about what to include and what relationships are involved.

It is the identification and categorization of relationships which represent the most time-consuming part of the exercise. In describing procedures for concept mapping, Jones, Palincsar, Ogle, and Carr (1987) have identified three different types of maps, namely, spider maps, chain maps, and hierarchy maps, in which relationships are usually named and identified on the representation, either written between the concepts or included in a legend, and which facilitate the generation of propositions. Propositions, which consist of the concepts which are connected and their relationships, can be generated by forming a sentence using the connected concepts and their relationship (West et al., 1991). The generation of propositions has been considered to be integral to the mapping process in much of the spatial learning strategy literature.

The categorization of relationships, as we have seen, is important to the networking and mapping strategies more specifically described in the previous section. Based on the work of Armbruster and Anderson (1984), Huang (1988), and McAleese (1985, 1986), West et al. (1991) similarly identified nine kinds of important relationships between concepts, namely, is an instance of, is a property of, is identical to, is similar to, is not similar to, is greater (less) than, occurs before, causes, and enables.

There is reason to believe that the categorization of linking relationships imposes a heavy processing burden on the mental operations of the user and requires additional time for learning and application. In addressing this concern, Holley and Dansereau (1984b) suggested limiting the number of relationships to be represented, and recommended as a possibility that students learning networking begin with practice in identifying key concepts and laying them out spatially. Filling in the relationships could be reserved for later training.

A simplification of the routines used should reduce the mental load implied in the use of these strategies, without detracting from the benefits. For example, the technique of "procedural facilitation", which consists of "routines and external aids designed to reduce the processing burden involved in taking on the advanced self-regulatory strategies of the expert" (Scardamalia & Bereiter, 1986, p. 70), has been successfully used in the teaching of writing (e.g., Scardamalia & Bereiter, 1983). Such simplification, applied to cognitive mapping strategies, may make these strategies more accessible to learners.

West et al. (1991) suggested that the focus on types of relationships may not be needed in all instructional applications. Our interest in this study, in replicating the activities of a deep learner, is to assist others in the activity of building connections between ideas in the formulation of mental representations. Our focus is on highlighting the connectedness of ideas, rather than the correct naming of specific relations between ideas, which requires time-consuming training in the ability to categorize the types of links made and to make correct links. Holley and Dansereau (1984b) suggested that less structured techniques allowing learners to develop their own links in fact may be beneficial foı some learners.

We therefore propose a simplification of procedures that would focus primarily on the linking of ideas presented in a passage of text. Such a method would not require extensive training for the learner. What is essential for the purposes of this study is that the learner be able to actively engage in the task of interrelating ideas.

Acquiring knowledge from text. According to our current understanding of mental processes, learners internally construct their own representation of any given subject matter. We refer to this representation as an organized internal knowledge structure or mental model. This process is essential to learning, which, if adopting the current cognitive perspective, can be described as "an internal structuring of knowledge" (West et al., 1991).

In br dging this concept to knowledge acquisition from text, we are interested in the representation the learner constructs of the text read. The concept of mental models can be specifically applied to text comprehension; mental model theories in this context refer to the reader's representation of information presented in text.

On the basis of their studies of text processing, Baudet and Denhière (1991) have contended that cognitive representations "are not those of the text but rather of the objects, states, events, actions and relations represented in the text" (p. 158). The assumption is that readers construct a mental model analogous in structure to that described by the text (McNamara, Miller, & Bransford, 1991). According to Schallert, Ulerick, and Tierney (1984), in the process of constructing such representations, the reader's task can be interpreted as that of reconstructing the author's intended structure and meaning:

> Although the major clues to the author's intended message are the actual words used, the message is the ideas and relationships between ideas that the author hoped students would learn about the topic. (p. 256)

What is of interest is the subjective nature of the process, as learners build representations of text based on their understanding of its content. These representations are not only constructed from information in the text, but also from the learner's existing knowledge and beliefs. Baudet and Denhière (1991) have referred to the process as follows:

> Knowledge acquisition from a text occurs basically by means of gradual attachment during text processing of what is being said in the text to the representation already built in memory. (pp. 158-159)

As a consequence, we cannot assume that learners will emerge with a common mental model when studying a text passage. As further described by Baudet and Denhière (1991):

> The content of the text can . . . be represented mentally in various ways. . . . Since every text contains for every reader what he is capable of understanding and ready to understand in the actual situation, the whole is not the same in every case and there is no definite means to tell when there will be the "total" whole. . . . Thus, talking of the representation of the text, will in our case not say that we try to solve the problem of "the" mental format of "the" representation and the problem of completeness of such a representation. (p. 46)

In fact, it is possible, even likely, that a learner may hold several mental models of the same text, depending on the individual's state and as determined by the context. Baudet and Denhière (1991) have suggested that the individual may construct "several types of representations of information born by the text, which are more or less distant from the surface of the text and which are more or less privileged as a function of the demands of the task" (p. 155).

Objectively speaking, according to Kimble (1979) and others, text prose can be considered to be a network of interrelated ideas, and its organization can be described in terms of the structure of these networks. The activity of cognitive mapping involves the learner producing a map which illustrates his or her interpretation of these networks.

The process of mapping a text passage therefore becomes a subjective process based on the individual's interpretation of content. Schallert et al. (1984) have described this process in terms of the learner exercising a choice in the selection of ideas and in their linkage:

> Subjectivity is involved in deciding what is a concept, what is the major topic of a text, what are the main structural relationships presented by the author (what is the overall shape of things), and what is explicitly stated in the text. (p. 271)

The learner can be said to construct a cognitive representation of what he or she believes is being expressed in the text. Our interest in the cognitive mapping process is with the activity of interrelating ideas, and the ability to create overall structural relationships among ideas, not on the correctness of these relationships and of the overall representation. In this research project we are not concerned with the accuracy of the match between the learner's imputed representation of relationships and the author's intended representation of relationships.

The activity of cognitive mapping focuses the learner on the task of identifying and linking concepts. In its emphasis on "anchoring ideas" and on providing a framework for linking together these ideas and their relationships, an initial mapping activity in the reading of text can be viewed as a form of advance organizer (Entwistle, 1987). This notion is supported in Dansereau et al.'s (1979) description of the networking strategy as one in which "students create their own implicit advance organizers on the first reading and then use this information on a second pass through the material" (p. 7). Similarly, in describing the process of *web learning*, Norman, Gentner, and Steven (1976) have recommended that students learn material in successive passes, the first of which should create a network, or web, of key concepts, while subsequent passes would allow the learner to fill in the details. We will base our simplified procedure on the premise that constructing a map of interrelated concepts will assist the learner in understanding a text passage.

Cognitive mapping and meaningful learning. The growing body of research related to cognitive mapping, including its application to text comprehension, provides increasing evidence of its potential effectivess as a learning strategy. By requiring the learner to identify key concepts and their interrelationships, and to then represent them spatially, cognitive mapping strategies may provide a means of ensuring that the learner builds a mental representation of text material.

McKeachie (1984) has attributed the success of these strategies to the fact they facilitate greater elaboration of the material requiring the learner to process information at "greater semantic depth". One way the exercise of model building may help learners assimilate information is by requiring them to actively attend to relationships.

Ausubel (1963) used the term "meaningful learning" to describe the process of establishing non-arbitrary relationships among concepts in the mind of the learner (p. 23). More recently Mayer (1989) has described the conditions for building meaningful learning outcomes: "Meaningful learning requires that students attend to relevant information, build internal connections among the pieces of information, and build external connections between the information and relevant existing knowledge" (p. 47). As a learning strategy, cognitive mapping appears to meet the criteria for facilitating such meaningful learning to take place.

What is key is the understanding that these internal knowledge structures or mental models are the result of a constructive process in which learners build internal representations of their experiences (e.g., Bruner, 1966;

Winograd & Flores, 1987), and thus in fact represent abstractions from experience, helping the individual understand the world and deal with it (Howard, 1987).

Other techniques which show promise in assisting learners to build mental models include providing text-provided aids such as *definitions pretraining*, that is, providing definitions of key terms that represent the important concepts in the model, and "signaling" key relations through the text to help learners organize links among key concepts (Mayer, Dyck, & Cook, 1984). Other studies have shown the beneficial effects of providing clear models to learners (Bayman & Mayer, 1984; Bromage & Mayer, 1981; Mayer, 1975, 1976, 1981). These techniques to encourage students to build mental models are differentiated from cognitive mapping strategies performed by the learner insofar as they represent text-provided aids.

Providing a model-building strategy to learners who do not naturally build link ideas when reading text, and who consequently focus on surface features of the text and rely on rote memorization, may well provide them with a means to promote meaningful learning. Novak (1990) proposed that concept mapping, defined in his research as a "representation of meaning or ideational frameworks specific to a domain of knowledge, for a given context of meaning" represents a "useful tool that could move students from learning by rote to learning meaningfully" (p. 32).

We would like to note again at this time that our definition of cognitive mapping encompasses the wide variety of strategies that require the learner to visually represent relationships among ideas; these strategies include concept mapping, spatial learning strategies, and other similar strategies referred to earlier.

Individual differences in the use of cognitive mapping. In reviewing the related literature, we see evidence of individual differences as we find indications in some studies that learning a cognitive mapping strategy may not be beneficial for all students. In the study we discussed earlier, Holley and Dansereau (1979), for example, found that students with low grade point averages (GPAs) who learned networking outperformed control students with low GPAs on both a "main ideas" measure of text comprehension and a "details" measure, whereas students with high GPAs who learned networking were outperformed by the control group on the details measure. Also, interestingly, the study revealed that the high and low GPAs demonstrated equivalent performance on the main ideas measure.

Holley and Dansereau (1979) have suggested that the high GPAs in their study already possessed effective learning strategies prior to the study and these served to compete with the new strategy. Of significant interest is the fact that students with low grade point averages demonstrated the greatest improvement. Whether or not they engaged in surface processing was not investigated.

In investigating the effectiveness of concept mapping as an instructional strategy for high school biology, Schmid and Telaro (1990) also found evidence of individual differences. Concept mapping was demonstrated to be beneficial to learners with lower reading ability, who outperformed nonmapping, lower ability readers on the completion of a multiple choice test, and performed at par with higher ability readers in both mapping and nonmapping conditions. Higher ability readers were reported to have found concept mapping to be initially disruptive.

Evidence of individual differences was also demonstrated in a study reported by Bernard and Naidu (1992), where differences were found in the level of "persistence" of subjects in completing concept mapping exercises and in their performance on certain measures of outcome. In discussing this research, Naidu (1991) pointed out that the evidence suggests that concept mapping may have greater potential for essay measures of performance, while it appears to impede performance on multiple choice tests, at least during initial stages of learning.

In reviewing 20 studies on the use of conceptual models as a technique for improving students' understanding of scientific explanations, Mayer (1989) found evidence of individual differences based on student aptitude for the material given (i.e., preexisting knowledge and capacities of the learner). It was found that when low aptitude students were tested for conceptual recall, the model (treatment) group consistently outperformed the control group. In looking at high aptitude students, however, the model (treatment) group performed at par with the the control group (Mayer & Bromage, 1980). In explanation, Mayer (1989) has suggested that:

> Less skilled students are most likely to benefit from direct instruction in how to construct a conceptual model for the to-be learned material, whereas more skilled students are likely to already possess and spontaneously use sophisticated conceptual models that may conflict with models presented during instruction. (p. 44)

High aptitude students, on the other hand, according to Mayer (1989), are "more likely to come to the lesson with already existing models (or the ability to construct them); for these students, the simplified, teacher generated models in the model groups may conflict with their more sophisticated models" (p. 61).

Consistent with these findings, as well as those of Holley and Dansereau (1979), according to the literature in instructional psychology, learning to apply new techniques can impede the performance of high-ability individuals, even though it may improve performance for low and average performers (Dillon, 1986). New strategies may be incongruent with the high-ability individual's existing strategies, already effective. Imposing the application of new strategies may therefore serve to have a negative impact on these individuals' performance. According to Corno and Snow (1986), cognitive strategy training seems to "intrude upon and interfere with the performance of more able learners" (p. 620).

Hewson and Posner (1984) have reported an interesting example of differences in the perceived helpfulness of using an instructor-provided schema to organise a university course. Students in an introductory physics course were taught the schema of "change", described and illustrated in terms of "concept nodes" and "slots", to help them develop a coherent view of the topics covered in the course. It is interesting to note two extreme cases of student reactions to the use of this schema: One student found the schema helpful not only in providing a framework for understanding material covered in class, but also in helping him organise the course material and relate it to the world. Another student reported that the schema was unhelpful, and did not appear to have an interest in organising the course material or in using the schema to do so. Such different reactions to the use of this schema may be indicative of a difference in learning approaches (Howard, 1987).

It may be helpful to refer to the notion of process schema in interpreting the results of some of these studies. A number of recent studies demonstrate that students have their own process schemata to understand particular domains; these schemata are greatly resistant to change (Howard, 1987). It may be that the use of a strategy conflicts with a learner's process schemata for understanding text, for example. The imposition of a particular "algorithmic structure" in a task may serve to "interfere with the able learner's own preferred processing style" (Snow, 1989, p. 49).

One may also consider interpreting these results in terms of the concept of negative transfer, defined "as a situation in which prior learning interferes with subsequent learning. It occurs when two tasks are highly similar but require different responses" (Biehler & Snowman, 1993, p. 461).

In their research on concept mapping, Novak and Gowin (1984) found that a certain percentage of students (approximately 5 to 20%) demonstrate a negative response to instruction requiring meaningful learning. According to Novak and Gowin, this will manifest itself as a resistance to concept mapping. A similar percentage of learners will have a very positive response, finding that the strategies "help them do 'just what they were trying to do'" (Novak & Gowin, 1984, p. 159). Differences in learning approaches may well account for these differences in response.

Quantitative Versus Qualitative Assessments of Learning

In general, it is possible to evaluate learning on a quantitative basis (e.g., amount of content remembered, number of correct points provided) or on a qualitative basis (e.g., whether the points are well-stated, interrelate, or are original). In both educational practice and research, quantitative assessments have taken precedence over qualitative ones to evaluate student learning (Biggs, 1979; Biggs, 1982, 1988a; Marton, 1976). It is important to note that research in evaluation is demonstrating that measures of quantitative differences do not necessarily relate to measures of qualitative differences (Trigwell & Prosser, 1991). As Entwistle (1987) has noted: "Unfortunately, tests which emphasize factual recall will not provide adequate evidence of conceptual understanding" (p. 39).

Since the objective of the current study is to promote meaningful learning, it is appropriate that we use qualitative measures of learning outcomes. Outcome of learning refers to the knowledge that the student acquires as a result of the learning process, which in turn refers to the way in which the information to be learned has been encoded (Mayer, 1989).

As noted previously, research studies investigating the effectiveness of learning strategies have relied on various measures of outcomes, including conventional objective and essay tests. Reviewers of the research have criticised the use of these formats (e.g., McKeachie, 1984; West et al, 1991). Surber (1984), for example, has decried the "insensitivity of traditional test formats to structures of knowledge." Testing practices have been widely called into question (e.g., Gould, 1981; Hoffman, 1962).

The failure to find evidence supporting the effectiveness of various learning strategies, for example, advance organizers, has been attributed to inadequacies in the use of dependent measures (e.g., Kember, 1991; Mayer, 1979). This reminds us of Ausubel's (1978) original criticism with regard to the advance organizer research, that is, that many studies do not distinguish meaningful learning from rote learning.

In discussing the limitations of traditional dependent measures "of overall amount recalled and/or overall performance on comprehension tests", Mayer (1989) has suggested that, in general, research "has not focused on cognitive analyses of students' learning and thinking processes as measured by dependent measures that go beyond overall amount retained" (p.47). Conventional measures, according to Mayer (1989), would not have been able to provide the information on students' understanding required in his research, namely, information on how mental models assist learners in selecting, organizing, and using information. Marton (1988) also has noted the need to use appropriate measures that are congruent with the objectives of the research.

Assessing meaningful learning. The assessment of meaningful learning requires an appropriately sensitive dependent measure. As Johnson (1975) concluded in his review of the research on meaningful learning, "Meaningfulness is potentially the most powerful variable for explaining the learning of complex verbal discourse" (pp. 425-426). In choosing the appropriate measure for the purposes of the current research, we were interested in obtaining information regarding a learner's ability to form relationships between ideas as a determinant of qualitatively different learning outcomes.

In the initial research on learning approaches conducted by Marton (1975) and Marton and Säljö (1976), a clear distinction was drawn between the qualitatively different outcomes resulting from surface and deep approaches. This research was able to establish an association between qualitatively different approaches and qualitatively different learning outcomes.

A clear relationship has been consistently demonstrated in these studies between deep level processing and quality of learning outcome (Säljö, 1982; Watkins, 1983). Qualitative levels were distinguished in terms of how the learner construed the structure of the content to be learned. Categorization of students' descriptions could be described in terms of taxonomic level of outcome and the form of expression used (Ramsden, 1985b). The lowest levels represented a restatement of the question, while the highest levels involved the elaboration of a key relating concept in the text.

In classifying the quality of what students' remembered from a chapter on the consequences of school drop-outs, Marton and Säljö (1976) used the following evaluation scheme:

Category A subjects were conclusion oriented and commented on the causes and consequences of the problem.

Category B subjects described what the author said without including causes, consequences, or conclusions.

Category C subjects treated the topic only very superficially and merely mentioned the topic that the author had discussed.

In investigating the issue of learning approach and type of learning outcome, Biggs (1979) developed a less subjective means of assessing learning quality, namely, the Structure of Observed Learning Outcome (SOLO) Taxonomy. It was initially developed to measure the quality of open-ended responses to a question designed to elicit depth of understanding in a learning task based on reading a text passage (Biggs, 1979). The SOLO Taxonomy parallels Marton's conception of levels in providing a means of assessing learning quality, and in effect represents its standardization (Watkins, 1983). It also corresponds notionally to Piaget's developmental hierarchy (Biggs, 1979).

SOLO consists of a classification scheme which categorizes specific responses to a learning situation in terms of five types of outcomes related to structural complexity (Biggs & Collis, 1982):

> (1) prestructural, comprising an irrelevant or inadequate component;
>
> (2) unistructural, in which only one out of a range of several possible components is used;
>
> (3) multistructural, where several relevant components are utilised, but they are not integrated to achieve maximal effect;
>
> (4) relational, where several components are used and are interrelated; and
>
> (5) extended abstract, in which a pattern of interrelated components is viewed as an instance of a more general case, and is extended to new contexts.
>
> (p. 61)

These five types of outcome in discourse structure are increasingly structurally complex with the first three types of outcomes linked to a surface approach to learning and the last two types linked to a deep approach, thus representing two qualitatively different types of learning outcomes. Biggs (1979) has described the taxonomy as coinciding "with a generalised version of Marton's notion of levels" (p. 385).

Watkins (1983) found a strong relationship between learning approach as determined by scores on Entwistle's Approaches to Studying Inventory and learning outcome as classified according to the SOLO Taxonomy. Learning approaches of university students were classified on the basis of depth of processing (i.e., surface or deep) and their responses to the learning task were classified as low SOLO (types 1, 2, or 3)or high SOLO (types 4 or 5). A chi square test was conducted with the calculated value of chi square found to be significant at the .01 level.

In attempting specifically to link Marton and Säljö's (1976) distinction between deep- and surface-levels of approach to learning with the SOLO Taxonomy, Van Rossum and Schenk (1984) applied SOLO in the categorization of learning outcomes as follows. Subjects' intentions in approaching text were first classified as surface level or deep level, then their responses to an essay question were categorized according to type of SOLO outcome. Two categories of SOLO outcomes were instrumental in analysing the answers, namely, multistructural (the highest SOLO category associated with surface responses) which described responses "characterized by the fact that several main points of the studied material are included without trying to connect them in any way" and relational (the first SOLO category associated with deep responses) which described outcomes containing main ideas and "a relating concept" which "is used to show how these main points are inter-related" (p. 79).

The researchers found a strong relationship between approach and learning outcome (e.g., all 35 students classified as surface provided multistructural responses, while 28 of the 34 students classified as deep provided relational or extended abstract responses). Van Rossum and Schenk have noted that the category of learning outcome of a surface approach is never found to be higher than multistructural; they have also concluded that Marton and Säljö's (1976) types of outcome (deep and surface) and the classification scheme of the SOLO Taxonomy are "almost identical" "in the practice of research" (p. 75).

In sum the SOLO Taxonomy appears to be a potentially useful tool in determining the quality of learning outcomes. In using an appropriate assessment measure to evaluate meaningful learning, such as SOLO, we will be adopting a "holistic" approach to measurement in the current study, and will be addressing a basic research flaw noted by Marton (1988):

> If researchers segment data on the learners' performance and experience into parts which are focused on without relation to each other, that is, if they adopt an atomistic approach in their research, they will fail to see whether or not the learner discovered the basic structure of the text. (p. 68)

Theoretical Hypotheses

In this section, theoretical hypotheses to be investigated in the study will be presented first, followed by theoretical definitions of relevant terms.

Hypothesis 1. Subjects who apply a *cognitive mapping strategy* when reading text will demonstrate greater evidence of *meaningful learning* than subjects who do not.

Hypothesis 2. Subjects whose typical approach to learning is *deep* will demonstrate greater evidence of meaningful learning when reading text than subjects whose approach to learning is *surface*.

Hypothesis 3. Subjects whose typical approach to learning is surface and who apply a cognitive mapping strategy when reading text will demonstrate greater evidence of meaningful learning than subjects whose approach to learning is surface and who do not apply a cognitive mapping strategy.

Hypothesis 4. Subjects whose typical approach to learning is deep and who apply a cognitive mapping strategy when reading text will demonstrate less evidence of meaningful learning than subjects whose approach to learning is deep and who do not apply a cognitive mapping strategy.

Theoretical Definitions

Cognitive mapping strategy. Cognitive mapping refers to a strategy which requires the learner to produce a visual representation (map) of his or her interpretation of the network of interrelated ideas presented in a passage of text.

Meaningful learning. Meaningful learning refers to the process of establishing non-arbitrary relationships among concepts in the mind of the learner, that is, of building internal connections among ideas.

Deep approach to learning. A deep learning approach refers to the tendency of the learner to search for the meaning inherent in a learning task and to integrate the parts of the task into a whole.

Surface approach to learning. A surface learning approach refers to the tendency of the learner to regard a learning task as a demand to be met and to focus on reproducing the surface aspects of the task through memorization.

CHAPTER THREE

Method

In this chapter the procedures used to conduct the research will be described in detail. A description of the sample will be provided, as well as a description of how subects were selected and assigned to treatments. The specific instruments used to obtain information related to the problem and the hypotheses will be fully described in operational terms. A summary will be given of the specific steps followed in implementing the research investigation. Operational hyotheses and definitions will be presented for the variables relevant to the study.

Subjects

The sample consisted of 172 pupils attending an urban Canadian high school (Westmount High School in Westmount, Quebec). All three Grade 8 classes and all three Grade 9 classes at the high school comprised the six intact groups used in the study. The subjects can generally be described as English-speaking, representing a variety of ethnic and socio-economic backgrounds, and ranging from 13 years of age to 16.

The following data were eliminated from statistical analysis: (a) data from subjects who were absent during any of the sessions (students in the control group were required to attend both sessions conducted for that group and students in the experimental group were required to attend all four treatment sessions), (b) data from those subjects who were unable to understand written or spoken English (e.g., recent immigrants to Canada), and (c) data from students in the treatment group who did not complete a map in the test during the final session (this accounted for five students). As a result, complete data sets for analysis were available from only 118 pupils (66 male, 52 female).

The research was conducted in all six of the eighth- and ninth-grade English classes during a one-month period in the final term of the 1991-1992 school year. The six English classes were taught by four different teachers. The choice to use English classes was made in consultation with the principal and the head of the English department; it was based on the premise that the skills to be taught and tested were most applicable to the objectives of the school's English studies curriculum.

Due to constraints imposed by the school, namely the request to minimize disruption to normal routine and keep pupils in intact classes, it was not possible to randomly assign subjects to test conditions. Therefore, instead, each of the six intact classes was randomly assigned (i.e., coin toss) to a test condition.

One Grade 8 class and two Grade 9 classes made up the control group totalling 73 pupils (52 subjects with complete data sets). The treatment group was comprised of 99 pupils (66 subjects with complete data sets) in the other two Grade

8 classes and one Grade 9 class. The number of students from each class for both conditions is presented in Table 1.

Table 1

Distribution of Subjects by Condition

	Condition	
Class	Experimental	Control
Grade 8		
Section A	21(31)	0
Section B	27(36)	0
Section C	0	19(32)
Grade 9		
Section A	18(28)	0
Section B	0	14(17)
Section C	0	19(27)
Total	66(95)	52(76)

Note. Numbers in parentheses refer to initial distribution of students.

Design

This study was carried out using a version of a posttest-only control group design (Campbell & Stanley, 1963) with random assignment of intact groups to an experimental or control condition. When random assignment of individuals to treatments is not possible, the random assignment of intact groups represents a variation on the random assignment concept (Moore, 1983). The use of designs in which groups are randomly assigned to conditions, the experimental group receives the treatment, and both groups are given a posttest is supported by Campbell and Stanley (1963).

The difficulty of achieving random assignment of individual students in school settings has been noted by educational researchers such as Slavin (1984):

> Because the purpose of schooling is to educate and socialize students, not to provide a laboratory for researchers, schools are often less than enthusiastic about disrupting class assignments during the school year, and are no more positively inclined toward making permanent class assignments on a random basis. (p. 33)

In addition, Slavin has concluded that:

> Furthermore, a randomly assigned group is itself an innovation in schools where tracking, student course selection, or other systematic assignments are the norm. A randomly chosen group of students who do not know one another may be so different from the typical

> classroom setting that research with such a group may have limited generalizability; in fact, any situation that allows for random assignment may already be so unusual that results from that situation may be difficult to apply to other settings. (p. 33)

Given the problems of individual random assignment in school research, Slavin (1984) has recommended an alternative: "A more practical procedure for much educational research is random assignment of classes (or schools) instead of students" (p. 34). With such random assignment of classes, Slavin has stipulated the requirement of at least three classes to be included in each condition to reduce the possibility of false treatment effects. This requirement was met in the current study with the random assignment of three classes to both treatment and control conditions.

We would like to note that when random assignment of intact groups occurs, the research design may be considered either experimental research or quasi-experimental research. The distinction can be made on the basis of how post-test scores are analyzed (Moore, 1983). If scores are analyzed on the basis of groups, then it may be considered an experimental design; if scores are analyzed on the basis of individuals, it may be referred to as a quasi-experimental design. As differences in the current study are to be analyzed on the basis of individuals, the research may be considered as quasi-experimental.

In this study, one independent variable was the type of student approach to learning: surface or deep. This independent variable is a classification variable considered to be a "personological characteristic" (Moore, 1983) or "subject variable", referring to a "more or less permanent characteristic" of the subject that can be measured (Keppel & Saufley, 1980, p. 9). Such variables are manipulated through the selection of subjects on the characteristic to be studied. In this case subjects were grouped together according to their learning approach. The second independent variable was defined as the type of instruction in cognitive mapping at two levels: instruction in cognitive mapping and no instruction. The study thus involved a combination of nonsubject and subject manipulations and constituted a valid application of the experimental method (Wood, 1974).

The dependent variable was meaningful learning as it refers to the ability to understand key ideas in a text passage and their interrelationships. It was measured in terms of the quality of learning outcome demonstrated in the subject's written response to an essay-type test on a text passage. Learning outcomes were categorized on the basis of evidence of meaningful learning as measured by the Structure of Observed Learning Outcome (SOLO) Taxonomy (Biggs & Collis, 1982), to be described later in this chapter in the section, "Instrumentation: Dependent Measure."

Classification of Subjects by Learning Approach

Choice of instrumentation. Instrumentation options for classification of students by learning approach were limited to those which could assess deep and surface approaches in secondary school students. The methodology applied in Marton's (1975) research did not provide a viable option; the "qualitative" interview approach to classifying subjects on learning approach has extremely lengthy time implications which precluded its use not only for the purposes of a study with the real-world constraints of the present investigation, but also for regular use by schools.

Using published evidence of validity and reliability, Curry (1990) recommended eight learning style instruments (chosen from over 100 such existing instruments) for use with secondary school students. Of those described, only those instruments which were relevant to the focus of the current research (and which thus could be linked to the conceptions of deep and surface approaches to learning described in the Gothenburg studies) could be considered appropriate. Possibilities consisted of Entwistle's Approaches to Studying Inventory (ASI) (Entwistle et al., 1979) and Biggs' Learning Process Questionnaire (LPQ) (Biggs, 1987). Upon investigation, Entwistle's ASI was not yet available for use in a customized version for high school students, leaving Biggs' LPQ as the remaining option available for this study.

The Surface and Deep Approach Scales in the LPQ have been described as conceptually related to the approaches described in the Marton research (Beckwith, 1991; Biggs, 1987; Biggs & Rihn, 1984; Ramsden, 1985b; Trigwell & Prosser, 1991). This conceptual link served to confirm the choice of this instrument for use in this study.

Learning Process Questionnaire (LPQ). Deep and surface approaches were operationalized using the Learning Process Questionnaire (LPQ) developed by Biggs (1987). It is a self-report instrument using five-point Likert scale items and designed to assess motives, strategies, and approaches used by secondary school students in studying and learning. Within this framework, an individual's approach to a given learning situation is viewed as a function of both a motive to use a particular strategy and the strategy itself. Scores are produced for both Deep and Surface Approaches to Learning, with subscale scores for Strategy and Motive on each approach.

As previously described, a learner who adopts a deep approach to learning searches for the meaning inherent in a learning task (i.e., motive) and integrates the parts of the task into a whole (i.e., strategy), while a learner who adopts a surface approach to learning regards a learning task as a demand to be met (i.e., motive) and focuses on reproducing the surface aspects of the task through memorization (i.e., strategy).

The instructions on the LPQ ask the students to respond to questions about their attitudes towards their studies and their usual ways of learning in school. The choice of answers based on the Likert scale range from 1 (never or only rarely true) to 5 (always or almost always true).

Sample questions from the questionnaire, demonstrating items assessing deep and surface approaches, are provided in Table 2.

Table 2

Sample Questions From the Learning Process Questionnaire (LPQ)

LPQ Subscale	LPQ Question
Surface Strategy	10. I find the only way to learn many subjects is to memorize them by heart.
Surface Motive	16. I prefer subjects in which I have to learn just facts to ones which require a lot of reading and understanding of material.
Deep Strategy	11. In reading new material, I am often reminded of material I already know and see the latter in a new light.
Deep Motive	17. I find that I have to do enough work on a topic so that I can form my own point of view before I am finished.

Question #10 is one of the 6 test items assessing surface strategy, while question #16 represents one of 6 items assessing surface motive. Likewise, question #11 is one item of six assessing deep strategy, while question #17 is one of six items assessing deep motive. Each set of six items comprises a subscale.

The LPQ is scored by summing the responses to the items comprising each subscale. The sum of both motive and strategy subscales then yields the approach scale score. The result is a scale score for deep approach and a scale score for surface approach. To be classifed as having a deep approach, learners must score (a) above average on Deep Approach and (b) average or below average on Surface Approach. Likewise, to be classified as having a surface approach, learners must score (a) above average on Surface Approach and (b) average or below average on Deep Approach.

Since the questionnaire was designed for use with Australian students, the LPQ was slightly modified for this study to the extent that all questions would be understood by a Canadian high school student population, that is, the test item # 4, "I tend to study only what's set; I usually don't do anything extra" was replaced with "I tend to study only what's required; I usually don't do anything extra."

Reliability and validity of the LPQ. Sampling for the LPQ to determine norms initially involved a representative sample of all Australian students, namely 2500 students in Australian secondary schools, and was arranged through the

Australian Council for Educational Research to ensure accurate random sampling (Biggs, 1987a). Test-retest reliability measuring the consistency of LPQ scores over time (ranging from .49 to .72 for subscales and .60 to .78 for scales) are reported by Biggs (1987) as "reasonably stable" and "highly satisfactory". Measures of internal consistency as measured by the alpha coefficient (generally in the .70s) are also reported by Biggs as satisfactory.

Factor analysis demonstrated support for the scale structure (Biggs, 1987a). Correlations with self-rated performance were reported (Biggs, 1987a) as follows: surface approach had an average correlation of -.15, while deep approach correlated in the low +.20's. Correlations with High School Certificate (HSC) scores (i.e, school performance) ranged from .20 to .30, with surface approach having a negative correlation and deep approach having a positive correlation. Appropriate correlations with internal locus of control were also reported by Biggs (1985), however no figures have been published. Thus it appears that the LPQ has adequate construct validity.

LPQ scales were found to have significant relationships to qualitatively different types of performance in terms of learning outcomes (Kirby & Biggs, 1981), thus lending support to the validity of the instrument. In this study, which assessed outcomes in terms of the SOLO Taxonomy (to be discussed in greater detail later in this chapter), a canonical analysis (based on canonical correlations for LPQ scales, class performance, and SOLO level of performance), revealed a deep approach to be related to higher SOLO levels (defined in terms of greater structural complexity). A surface approach was associated with greater factual recall and lower SOLO levels.

Two separate reviewers of the LPQ (Brown, 1992; Hall, 1992) refer to the validity of the instrument as being supported through relevant studies and confirm that the reported reliability estimates for LPQ scale scores are satisfactory. In providing "summative psychometric ratings" for a number of available learning style instruments, Curry (1990) has ascribed "fair validity evidence" and "good reliability evidence" to Biggs' LPQ.

Andrews, Violato, Rabb, and Hollingsworth (1994) conducted a confirmatory factor analysis of Biggs' LPQ using a Canadian sample. Using structural equation modelling techniques, Andrews et al. found the overall fit of the data to the model to be very good with a comparative fit index of .97 and a residual mean square of .17, providing "strong support" for Biggs' factor structure (p. 179).

It is important to note that many known learning style instruments do not have published evidence of reliability and validity; Biggs' LPQ is one of eight learning style instruments (out of over 100 of such existing ones) that provides published evidence of reliability and validity (Curry, 1990).

Use of LPQ to classify subjects. The LPQ operationalizes deep and surface approaches to learning in terms of scale profiles "which represent an individual's general orientation to learning; that is, a composite of motivational states and strategy deployment that is relatively consistent over situations" (Biggs, 1987b, p. 3). A surface approach is thus operationally defined in terms of an LPQ profile which indicates a surface motive and strategy to be predominant; likewise, a deep approach is operationally defined in terms of an LPQ profile indicating a deep motive and strategy to be predominant. This operationalization is in line with the distinction between surface-level and deep-level processing made by Marton and Säljö (1976) (Biggs, 1987b). Other studies which have been concerned with links between learning approaches and learning outcomes have used similar types of operational definitions, for example, Watkins (1983) and Van Rossum and Schenk (1984).

In this study, subjects were individually categorized according to their learning approach on the basis of their scores on the Deep and Surface Approach Scales in the LPQ, which was administered at the beginning of the study (Phase 1). The following method was used to classify subjects: Raw scores on the Surface Approach Scale (maximum of 60 points) and the Deep Approach Scale (maximum of 60 points) were calculated and ranked from highest to lowest. Ranked learning approach scores were sorted into deciles. Deciles were categorized as follows in the manner recommended by Biggs (1987b): scores in the bottom 10% represented the "well-below average" grouping, the next 20% the "below average", the middle 40% the "average", the next 20% the "above average", and the top 10% the "well-above average" grouping.

To ensure that we did not consider people whose scores might be high on both deep and surface approaches, a fairly stringent requirement was imposed, namely that individuals scoring high on both scales would be excluded from these two classifications.

For the purposes of this study, students scoring (a) "well-above average" and "above average" on deep approach (i.e., the top 30%) and (b) "average" or "below average" or "well-below average" on surface approach (i.e., the bottom 70%) were categorized as using a deep approach (i.e., "LPQ-Deep"). Similarly, students scoring (a) "well-above average" and "above average" on surface approach (i.e., the top 30%) and (b) "average" or "below average" or "well- below average" on deep approach (i.e., the bottom 70%) were categorized as using a surface approach (i.e., "LPQ-Surface"). These categorizations were in accordance with the classification scheme employed by Biggs (1987b).

Description of Cognitive Mapping Strategy

The second independent variable under consideration in this study was the type of instruction in cognitive mapping strategy at two levels: instruction in cognitive mapping and no instruction. Cognitive mapping strategy refers to a spatial technique for representing the main ideas of a passage of text and their interrelationships. It provides a methodology for structuring information in graphic form.

In this study the methodologies of Hanf (1971) and Buzan (1982) were adapted into the following simplified steps referred to in the treatment condition classes as "idea mapping": (1) select a key idea (word or phrase) and write it on the middle of a sheet of paper, (2) select another key idea and link it to the previous one, (3) continue adding and linking ideas until you have finished the text passage, and (4) then circle the most important one(s).

A description of how this cognitive mapping strategy was taught to the subjects in the treatment condition is fully described in the "Instructional Treatment" section of this chapter.

Instrumentation: Measuring Meaningful Learning

The dependent variable *meaningful learning* was defined as the process of establishing non-arbitrary relationships among concepts in the mind of the learner, that is, of building internal connections among ideas. Within the context of reading prose it refers to the ability to understand key ideas in a text passage and their interrelationships. It was measured in terms of the quality of learning outcome demonstrated in the subject's written response to an essay-type test on a text passage.

Classification of Responses. Learning outcomes, that is, responses to the essay question, were classified as deep or surface using the Structure of Observed Learning Outcome (SOLO) Taxonomy (Biggs & Collis, 1982; Biggs, 1988) to assess meaningful learning. This taxonomy provides criteria for determining five increasingly complex levels of outcome in discourse structure. The first three levels are linked to a *surface* level of outcome and are referred to as: (1) *prestructural*, (2) *unistructural*, and (3) *multistructural*. The last two levels are linked to a *deep* level of outcome and are referred to as: (4) *relational* and (5) *extended abstract*.

At the surface level of outcome, in a prestructural response, the information produced in the written response is considered to be irrelevant. In a unistructural response, one item of relevant information is presented, while in a multistructural response, several pieces of relevant information are produced.

At the deep level of outcome, a relational response will provide relevant information that is interrelated with a conclusion that is derived from the analysis. An extended abstract response demonstrates the use of abstract concepts and a link to personal experience that provides a fuller, more formal explanation of ideas.

Biggs (1990) has discussed two types of shifts that can occur as learning progresses; the learner can move: (a) from a unistructural to a multistructural level, that is, "from knowing a little to knowing a lot about the topic" or (b) from a multistructural to a relational level, that is, from "knowing something about a topic" to "understanding its meaning and being able to make use of it" (p. 690). The first shift reflects a quantitative change; the second is qualitative.

Our concern in this study is with the latter shift. In operationally defining meaningful learning, we are interested in evidence of the building of internal connections among ideas in the mind of the learner. We need to determine whether or not the learner's response provided evidence of having linked ideas in the text; therefore, we are interested in two categories of response for our dependent variable. These two categories represent the two qualitatively different outcomes of the learning process: SOLO-Surface (i.e., the first three categories of the SOLO Taxonomy) or SOLO-Deep (i.e., the last two categories of the SOLO Taxonomy).

Assessment Procedure. The written responses were assessed by two raters working independently using the criteria in Table 3, which were based on descriptions provided by Biggs and Collis (1982). The raters underwent a practice session together in which they reviewed and discussed the criteria, then applied them to sample responses in a practice session. Scoring of all responses was performed "blind", that is, the raters were unaware of the identity of the authors and how each had been categorized by learning approach or grouped by condition.

A correlation coefficient was calculated to determine inter-rater reliability on assessing the responses on the basis of the five categories of the SOLO taxonomy and was found to be .84.

Table 3

Criteria for Applying the SOLO Taxonomy to Responses

SOLO Classification	Description of Response
SOLO-Surface	
1 - Prestructural	No response. Response is irrelevant to the question. Response only restates the question. Response does not address question.
2 - Unistructural	One relevant piece of data is provided: one fact or idea is expressed that addresses the question.
3 - Multi-structural	Two or more items of data addressing the question are provided. The data are isolated and not explicitly interrelated by the writer.

Table 3 (cont.)

Criteria for Applying the SOLO Taxonomy to Responses

SOLO Classification	Description of Response
SOLO-Deep	
4 - Relational	Two or more pieces of information are provided, interrelated by the writer. The writer attempts to relate the data into a coherent whole. Ideas taken from different paragraphs are presented with an attempt to make general sense of them.
5 - Extended abstract	The writer goes beyond a relational response by adding a level of abstraction, going beyond the information given. Relevant information is added that shows personal integration of information. Answer demonstrates that the writer has thought about the information and has given it a dimension of personal meaning.

Since it was necessary to determine a single classification for each written response for the purpose of conducting the statistical analysis required for this study, the raters reviewed and discussed each written response on which the ratings were not in agreement. The raters then came to an agreement on those items using the five categories of the SOLO taxonomy.

Examples of actual student responses (uncorrected) demonstrating the described SOLO Taxonomy criteria are provided in Table 4.

Table 4

Examples of Responses Demonstrating SOLO Taxonomy Criteria

SOLO Classification	Sample Responses
SOLO-Surface	
1 - Prestructural	"I learned nothing."
	"Your brain is big and theres a lot of numbers. That's all I should tell you though because I wouldn't want to ruin your experience of reading it."
	"I learned that we have brains."
2 - Unistructural	"People use 10 percent of the potential brain power. A lot of people use only 4% of the brain power than 10%. They left 96% lie unused."
3 - Multi-structural	"The article which I have read was about the human brain. After reading that article I am really impressed. I am really amazed that the brain has more than a billion cells. It is really

Table 4 (cont.)

Examples of Responses Demonstrating SOLO Taxonomy Criteria

SOLO Classification	Sample Responses
	amazing how all these cells fit in a human brain. The article which I read basically told all about the different type of brain cells. It also tells us about how the brain functions. The article also told about brain potential, brain power and brain functions. It also tells us how many functions the brain can possess. In conclution I'd like to tell you that I would like to read that article again if I can."
SOLO-Deep	
4 - Relational	"The article is about how our brain developes and how it works. It explains how we only use about 4% of our brain. It tells us we can use more of our brain. Brain power depends on the number of neurons and the

Table 4 (cont.)

Examples of Responses Demonstrating SOLO Taxonomy Criteria

SOLO Classification	Sample Responses
	richness of their connections, Neurons are the main part of our brain. They start developing first. Our brain contains 12-15 billion neurons. (A bee's brain contains only 7,000). If we use our brain alot it causes more connections between neurons and therfore we have more brain power. The article told about other parts of our brain and when they develop."
5 - Extended abstract	No responses received in this category.

Procedures

The research study can be described in terms of three phases carried out during a four-week period in the final term of the school year.

Phase 1 of the study. In the first session of meeting with each class in all treatment and control groups, the LPQ was administered to all students in the class. The researcher read aloud the instructions on the questionnaire, then asked the students to complete the questionnaire. All of the students were able to complete the LPQ within the 50-minute classroom period.

The LPQ was administered to all participating classes within a one-week period, "Week 1" of the research study.

Phase 2 of the study. During this phase, which was comprised of the second and third weeks of the study, the researcher conducted two instructional sessions, to be described in the "Instructional Treatment" section below, with each of the three classes in the treatment group. Each class underwent the first instructional session within a three-day period during "Week 2" of the research study. Then they underwent the second instructional session within a three-day period one week later, during "Week 3" of the study.

During this phase no sessions were conducted with the classes in the control group.

Phase 3 of the study. This phase took place during "Week 4" of the study. Students in both treatment and nontreatment conditions participated in a testing session, which was conducted as follows.

Students were asked to read a passage of text (see Appendix A for copy of text) and were instructed to make maps or notes of the material if they wished, as they were to be tested on their understanding of the content. Students were given a time limit of 30 minutes to complete this exercise. At the end of this activity, the articles and any notes or maps made were collected by the researcher (see Appendix B for examples of student maps).

Students were then administered an essay-type test designed to elicit their understanding of the content of the article (see Appendix C for copy of test). Students were told that they had the remainder of the class period to compose their answers. At the end of the class period all responses were collected by the researcher.

Testing sessions for all six classes were conducted within one four-day period.

Instructional treatment. Students in the treatment condition participated in two classroom sessions (separated by one week), conducted by the researcher, designed to facilitate learning of the cognitive mapping strategy. A combination of lecture, classroom discussion, practice, and review were used as instructional strategies. Strategies such as guided practice, providing feedback, and modelling behavior were used, based on known methods (e.g., Pressley & Levin, 1987; West et al., 1991) of stimulating mental involvement in the teaching of cognitive skills. Classes were 50 minutes in length.

During the first classroom session (Instructional Treatment-Part 1), pupils were gradually introduced to the cognitive mapping strategy, referred to in class as "idea mapping", through a series of exercises. After a brief introduction intended to increase the students' level of motivation, the class was introduced to the idea of mental "pictures" through two brief exercises. The researcher then guided the class through a large group mapping exercise on the blackboard. After completion of this exercise, students were asked to pick an idea of personal interest and to try making their own idea map. The researcher circulated throughout the room during this activity, providing encouragement and comments to students on their work.

After everyone had completed a map, the maps were collected (see Appendix D for examples) and a transition was made by the researcher to the topic of mapping ideas from text, that is, using the technique to better understand what they read. An exercise was handed out (see Appendix E for copy of exercise) for the purpose of practicing the mapping strategy with individual paragraphs of a passage of text on the topic of idea mapping. The researcher guided the students through the first two paragraphs in a large group exercise, then asked the class to complete the remainder of the exercise on an individual basis. After the students had completed mapping each paragraph in the exercise, they were asked to link the ideas from each paragraph on the exercise sheets to show how the ideas were related. At the conclusion of this exercise the researcher summarized the lesson's activities and passed out an article to be mapped as an assignment for the next session. The article, designed to be also motivational in nature, discussed the transformation of an ineffective learner, high school student Edward Hughes ("C" student), into an effective learner (highest exam scores at Cambridge University) through the use of mapping techniques (see Appendix F for copy of article).

In the next instructional classroom session (Instructional Treatment-Part 2), approximately one week later, the researcher began by reviewing the first session, emphasizing key concepts. The main steps involved in mapping were reviewed. The researcher then handed back the exercise students had worked on in the previous class, and asked the class to map the entire article on a separate blank sheet of paper with the objective of linking the main ideas in the article. Then the researcher mapped her own version of an idea map of the article on the board, emphasizing that each student's map will look different, but will still represent a valid interpretation of the article. The students were then asked to personalize their maps by adding their own observations, conclusions, and graphics. The researcher collected the maps (see Appendix G for examples), then conducted a mapping exercise on the Edward Hughes' article passed out the previous week. Students were asked to map keywords and ideas on the blackboard in a large group classroom exercise. At the conclusion of the exercise, another assignment (an article "Root Causes" from *Green Magazine*, April 1992) was handed out as a homework practice assignment.

Operational Hypotheses

The theoretical hypotheses presented in Chapter Two have been operationalized as follows:

Hypothesis 1. Students who apply a *given cognitive mapping strategy* (see definition below) when reading a text passage will demonstrate greater evidence of *SOLO-Deep* responses in a text comprehension task than students who do not apply the strategy.

Hypothesis 2. Students classified as having *a deep approach to learning* on the basis of their scores on Biggs' Learning Process Questionnaire (LPQ) will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students who are classified as having a surface approach.

Hypothesis 3. Students classified as having *a surface approach to learning* on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students classified as having a surface approach and who do not apply the given strategy.

Hypothesis 4. Students classified as having a deep approach on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate less evidence of SOLO-Deep responses in a text comprehension task than students classified as having a deep approach and who do not apply the given strategy.

Operational Definitions

Cognitive mapping strategy. The given cognitive mapping strategy refers to a spatial technique for representing the main ideas of a passage of text and their interrelationships which involves the following simplified steps: (1) select a key idea (word or phrase) and write it on the middle of a sheet of paper, (2) select another key idea and link it to the previous one, (3) continue adding and linking ideas until you have finished the text passage, and (4) then circle the most important one(s).

SOLO classification. Responses (essay-type) to the text comprehension task were classified as deep or surface using the Structure of Observed Learning Outcome (SOLO) Taxonomy (Biggs, 1988; Biggs & Collis, 1982). A response was classified as *surface* (i.e., SOLO-Surface) if it met the criteria for any of the first three SOLO categories, i.e., prestructural, unistructural, or multistructural. A response was classified as *deep* (i.e., SOLO-Deep) if it met the criteria for either of the last two SOLO categories, i.e., relational or extended abstract. Exact criteria for these classifications are described in Table 3 in this chapter.

Deep approach. A student will be classified as having a *deep approach* if he or she scores (a) well-above average or above average on Biggs' LPQ scale measuring Deep Approach (i.e., the top 30%) and (b) average or below average on the scale measuring Surface Approach (i.e., in the bottom 70%).

Surface approach. A student will be classified as having a *surface approach* if he or she scores (a) well-above average or above average on Biggs' LPQ scale measuring Surface Approach (i.e., in the top 30%) and (b) average or below average on the scale measuring Deep Approach (i.e., in the bottom 70%).

Data Analysis

Selection of data for analysis. To ensure the integrity of the research, it was decided to eliminate data from subjects in the treatment group who did not complete maps during the testing phase. Five subjects in the treatment group did not complete maps and the data from these subjects were excluded from analysis. Similarly, it had been decided to eliminate from analysis data from subjects in the control group who completed maps. It was not necessary to eliminate any data for this purpose as no subjects in this group completed a map.

Statistical treatment. The dependent measure consisted of responses categorized as SOLO-Surface or SOLO-Deep in a dichotomous classification scheme. Nominal data of this type require the use of nonparametric statistical tests (Keppel & Saufley, 1980; Moore, 1983; Siegel, 1956; Slavin, 1983). Nonparametric statistics are also required when the normality of the distribution of scores cannot be assumed

(Keppel & Saufley, 1980; Moore, 1983; Siegel, 1956; Slavin, 1983), as in this study.

The chi square statistic was selected as the appropriate nonparametric analytical treatment since the variables in a chi square analysis are always categorical and result in data that are frequency counts. In using the chi square statistic, special rules apply when there is one degree of freedom, namely the need to apply a correction for continuity, i.e., the Yates' Correction if any expected frequencies are smaller than 10 but larger than or equal to 5, or the need to perform the Fisher Exact Test if one or more of the expected frequencies are smaller than 5 (Keppel & Saufley, 1980). When and as required, depending on the size of the expected frequencies in cells, the Yates' Correction or the Fisher Exact Test was performed. Due to the size of the frequencies appearing in the data analysis for this study, the Fisher Exact Test was the test most frequently used.

CHAPTER FOUR

Results

Results of the analyses of the data collected in the research will be presented in this chapter.

Source of Data

The data to be analyzed were derived from an essay-type test administered to subjects during Phase 3, the final phase of the study. The test was administered within three to four weeks after Phase 1 (the administration of the Learning Process Questionnaire), as the school schedule permitted. Tests for all six classes were administered within an 8-day period in the third term of the school year.

Variables in the Design

Independent variables. There were two independent variables in this study. One was type of instruction in cognitive mapping, which consisted of two levels: instruction or no instruction. In the treatment condition, subjects were provided with instruction in a cognitive mapping strategy, while in the second condition, that is, the control condition, subjects were given no instruction.

The second independent variable was defined as type of student approach to learning, that is, surface or deep, described as a subject variable. The use of a subject variable entails the classification of subjects on the dimension to be studied, usually a permanent characteristic of the individual (Keppel & Saufley, 1980), in this case, learning approach. Such a variable is manipulated through the selection of subjects on the basis of how they are classified.

In this study, learning approach was manipulated by obtaining scores on the Learning Process Questionnaire for all the pupils in Grade 8 and 9 who were in class during Phase 1 of the study and then classifying subjects on the basis of their responses. The independent variable therefore consisted of subjects grouped by learning approach on the basis of the LPQ.

The number of students classified in each category (type of learning approach) is shown in Table 5. Students classified as "Other" were those who did not fall into either Deep Approach or Surface Approach categorizations, that is: (a) those who scored above average or well-above average on both the Surface and Deep Approach scales and (b) those who scored average or below average on both the Surface and Deep Approach scales.

Table 5

Frequency Distribution of Subjects Classified by Learning Approach

Learning Approach	Frequency	Percentage of Total
	Treatment group (*n*=66)	
Deep	12	18
Surface	13	20
Other	41	62
	Control group (*n*=52)	
Deep	9	17
Surface	10	19
Other	33	64

Equivalence of groups. A quick scan of the "Percentage of Total" column appears to reveal no differences between treatment and control groups in terms of distribution of subjects on the basis of learning approach. Because of the use of intact classes in this study, information on whether there were initial differences between the groups is helpful in establishing group equivalence. A chi square test was performed comparing treatment and control groups to statistically determine equivalence on the proportion of students categorized as LPQ-Deep. The resulting chi square value of 3.53 was found to be not significant at the .05 level, thus providing support for group equivalence on the basis of representation of deep approach. We note that establishing group equivalence on this basis may be considered problematical insofar as more research is required to confirm the actual relationship between LPQ scores and SOLO categorizations.

Dependent variable. The dependent variable consisted of the categorization of written responses to an essay question based on a passage of text. Responses to this text comprehension task were classified as either deep (SOLO-Deep) or surface (SOLO-Surface) using the Structure of Observed Learning Outcome (SOLO) Taxonomy (Biggs, 1988; Biggs & Collis, 1982) as previously described in Chapter 3.

A frequency distribution of responses by SOLO classification is provided in Table 6.

Table 6

Frequency Distribution of Responses Using SOLO Categories

SOLO Classification	Frequency	Percentage of Total
	Treatment group (n=66)	
SOLO-Surface		
(1) Prestructural	4	6
(2) Unistructural	5	8
(3) Multistructural	35	53
Total	**44**	**67**
SOLO-Deep		
(4) Relational	22	33
(5) Extended abstract	0	0
Total	**22**	**33**
	Control group (n=52)	
SOLO-Surface		
(1) Prestructural	13	25
(2) Unistructural	5	9
(3) Multistructural	31	60
Total	**49**	**94**
SOLO-Deep		
(4) Relational	3	6
(5) Extended abstract	0	0
Total	**3**	**6**

Hypotheses

Results obtained for each hypothesis will be described in turn.

Hypothesis 1. Students who apply a given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students who do not apply the strategy.

In analyzing the overall effect of cognitive mapping on learning outcome, observed frequencies as shown in Table 7 were compared with the expected values in Table 8. A chi square statistic was calculated and the resulting value of 13.24 was found to be *significant* at the .01 level. The proportion of SOLO-Deep responses within the treatment group was found to be greater than the proportion of such responses in the control group. The cognitive mapping treatment therefore was found to have a differential effect on learning outcome.

Table 7

Hypothesis 1: Observed Frequencies

Response Category	Condition: Treatment	Control	Total
SOLO-Surface	44	49	93
SOLO-Deep	22	3	25
Total	66	52	118

Table 8

Hypothesis 1: Expected Values

Response Category	Condition: Treatment	Control	Total
SOLO-Surface	52.02	40.98	93
SOLO-Deep	13.98	11.02	25
Total	66.00	52.00	118

Hypothesis 2. Students classified as having a deep approach to learning on the basis of their scores on Biggs' Learning Process Questionnaire (LPQ) will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students who are classified as having a surface approach.

The observed frequencies of SOLO classifications for students in the control sample are reported in Table 9. Expected frequencies are shown in Table 10.

Table 9

Hypothesis 2: Observed Frequencies

Response Category	Learning Approach Deep	Surface	Neither	Total
SOLO-Surface	7	10	28	45
SOLO-Deep	2	0	1	3
Total	9	10	29	48

Table 10

Hypothesis 2: Expected Values

Response Category	Learning Approach Deep	Surface	Neither	Total
SOLO-Surface	8.44	9.37	27.19	45
SOLO-Deep	.56	.63	1.81	3
Total	9.00	10.00	29.00	48

Since the chi square test may not be used if more than 20 per cent of the cells have an expected frequency of less than 5 (when $df > 1$), the "Surface" and "Neither Surface Nor Deep" Learning Approach (subjects classified as "Other" but excluding those classified as above average on both Surface and Deep Approach scales) categories were combined to increase the expected frequencies (as recommended by Siegel, 1956, p. 110). Using a larger n serves to increase the power of the test. The procedure used to classify students on learning approach had yielded smaller proportions of the total sample for analysis than anticipated (i.e., only 9 students of the total 52 in the control group were classified as LPQ-Deep and only 10 were classified as LPQ-Surface). It was considered appropriate here to combine the LPQ-Surface and LPQ-Neither Surface Nor Deep categories in investigating this hypothesis since our interest is in obtaining a measure of validity for the LPQ with respect to predicting SOLO-Deep responses in our sample and because the theoretical premises assumed a Deep/non-Deep dichotomy.

The new set of combined observed frequencies is shown in Table 11; expected frequencies are provided in Table 12.

Table 11

Hypothesis 2: Observed Frequencies With Combined Categories

Response Category	Learning Approach: Deep	Learning Approach: Surface/ Neither	Total
SOLO-Surface	7	38	45
SOLO-Deep	2	1	3
Total	9	39	48

Table 12

Hypothesis 2: Expected Values With Combined Categories

Response Category	Learning Approach: Deep	Learning Approach: Surface/ Neither	Total
SOLO-Surface	8.44	36.56	45
SOLO-Deep	.56	2.44	3
Total	9.00	39.00	48

As two of the expected frequencies were still smaller than 5, it was necessary to perform a Fisher Exact Test. The probabilities for the observed data met the criteria for applying a more powerful one-tailed version of the test, namely, Tocher's modification to the Fisher test (Siegel, 1956, p. 102). The procedures outlined for Tocher's modification were followed (Siegel, p. 103) with the resulting ratio of .56 found to be significant at the .05 level. In support of the hypothesis, a higher proportion of Deep-SOLO responses was therefore found in the group of students classified as LPQ-Deep in comparison to the group of students classified as LPQ-Surface or LPQ-Neither.

Hypothesis 3. Students classified as having a surface approach to learning on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students classified as having a surface approach and who do not apply the given strategy.

The observed frequencies reported in Table 13 were compared with the expected frequencies described in Table 14. Since two of the expected frequencies were smaller than 5, a Fisher Exact Test was performed. The observed data were shown to be *not significant* at the .05 level. The proportion of SOLO-Deep responses within the group of subjects in the treatment condition categorized as having a surface approach was not greater than the proportion of such responses within the group of subjects in the control condition categorized as having a surface approach. The cognitive mapping treatment therefore was not found to have an effect on learning outcome for this group of subjects.

Table 13

Hypothesis 3: Observed Frequencies

	Condition		
Response Category	Treatment	Control	Total
SOLO-Surface	12	10	22
SOLO-Deep	1	0	1
Total	13	10	23

Table 14

Hypothesis 3: Expected Values

	Condition		
Response Category	Treatment	Control	Total
SOLO-Surface	12.43	9.57	22
SOLO-Deep	.57	.43	1
Total	13.00	10.00	23

Hypothesis 4. Students classified as having a deep approach on the basis of their responses to Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate less evidence of SOLO-Deep responses to a text comprehension task than students classified as having a deep approach and who do not apply the given strategy.

The observed values shown in Table 15 were compared with the expected frequencies provided in Table 16. Since one of the expected frequencies was smaller than 5, a Fisher Exact Test was performed. The data were *not significant* at the .05 level. The proportion of SOLO-Deep responses within the group of subjects in the treatment condition categorized as having a deep approach was not less than the proportion of such responses within the group of subjects in the control condition categorized as having a deep approach. As the cognitive mapping treatment therefore was not found to have a differential effect on learning outcome for students classified as deep, Hypothesis 4 was not supported.

Table 15

Hypothesis 4: Observed Frequencies

	Learning Approach: Deep Condition		
Response Category	Treatment	Control	Total
SOLO-Surface	7	7	14
SOLO-Deep	5	2	7
Total	12	9	21

Table 16

Hypothesis 4: Expected Values

	Learning Approach: Deep Condition		
Response Category	Treatment	Control	Total
SOLO-Surface	8.00	6.00	14
SOLO-Deep	4.00	3.00	7
Total	12.00	9.00	21

Expanded Analysis

In our analysis of Hypothesis 1, we found an overall treatment effect for cognitive mapping on the dependent measure, the SOLO classification. We did not, however, find a treatment effect in separate comparisons of (a) students classified as typically using a surface approach (Hypothesis 3) and (b) students classified as typically using a deep approach (Hypothesis 4).

In the interest of having a more comprehensive understanding of the treatment effect, it was decided to take into consideration the subjects who were classified as not having a dominant learning approach (n=64), i.e., those classified as LPQ-Neither Deep Nor Surface, some of whom yet appeared to benefit from the manipulation of the instructional treatment. Failing to take this group into consideration may obscure important distinctions that could help guide future research in the area.

It is possible to consider the learner who does not have a dominant approach to learning as another case of an ineffective learner. By that we mean that this type of learner is less likely to adopt a deep strategy in a learning task requiring a deep approach than the individual categorized as a deep learner.

Extended Hypothesis 3. Students classified as not having a predominant approach to learning on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students classified as not having a predominant approach and who do not apply the given strategy.

Observed frequencies, shown in Table 17, were compared with the expected values in Table 18. A chi square statistic was calculated for the given data, which required the application of the Yates' Correction for continuity because two of the expected frequencies were smaller than 10 but greater than or equal to 5 (Keppel & Saufley, 1980, p. 382). The value of chi square calculated as 11.12 was found to be *significant* at the .01 level. Cognitive mapping was thus found to have an effect on the learning outcomes of those subjects who were classified as not having a dominant approach to learning.

Table 17

Extended Hypothesis 3: Observed Frequencies

Learning approach:

Neither deep nor surface

Response Category	Condition: Treatment	Control	Total
SOLO-Surface	20	28	48
SOLO-Deep	15	1	16
Total	35	29	64

Table 18

Extended Hypothesis 3: Expected Values

Learning approach:

Neither deep nor surface

Response Category	Condition: Treatment	Control	Total
SOLO-Surface	26.25	21.75	48
SOLO-Deep	8.75	7.25	16
Total	35.00	29.00	64

Factor Analysis of Learning Process Questionnaire (LPQ) Deep and Surface Approach Subscales

It was suggested that a factor analysis of the LPQ be conducted to confirm the validity of Biggs' deep and surface factors for the student sample in the present study. A total sample of 157 students was used for this analysis, comprised of the 89 Grade 8 students (56.7 per cent of the sample) and 68 Grade 9 students (43.3 per cent of the sample) who completed the questionnaire in Phase 1 of the current study.

The technique applied to analyze this data was a Principal Components Analysis with varimax rotation. The four subscales were first intercorrelated using Pearson product-moment correlations resulting in the matrix represented in Table 19.

Table 19

Intercorrelations of the Learning Process Questionnaire (LPQ) Deep and Surface Approach Subscales

Subscale	DM	DS	SM	SS
Deep Motive (DM)	1.00			
Deep Strategy (DS)	.57	1.00		
Surface Motive (SM)	.15	.17	1.00	
Surface Strategy (SS)	-.04	-.14	.42	1.00

An orthogonal solution was used in the testing of the factor structure as the factors are assumed to be independent. Two latent variables were confirmed, demonstrating a factor structure congruent with Biggs' (1978) findings. As shown in Table 20, the loadings from Deep Motive (.87) and Deep Strategy (.89) are high, clearly identifying one factor (i.e., Deep Approach), as are the loadings on Surface Motive (.83) and Surface Strategy (.86), identifying the other factor (i.e., Surface Approach).

Table 20

Factor Loadings, Communalities, and Proportionate Variance Contributions for Principal Component Analysis and Varimax Rotation on Learning Process Questionnaire (LPQ) Deep and Surface Approach Subscales

Subscale	Factor 1	Factor 2	Communality
Deep Motive (DM)	.87	.05	.75
Deep Strategy (DS)	.89	-.02	.79
Surface Motive (SM)	.24	.83	.74
Surface Strategy (SS)	-.18	.86	.77
Proportion of Variance	.53	.47	

In terms of the factor density of the variables, the average variable complexity was found to be low (1.06). The Surface Motive Subscale was found to be the most factorially dense (1.16) when compared with the other variables, that is, Surface Strategy (1.09), Deep Motive (1.01), and Deep Strategy (1.00).

The proportionate variance contributions of both identified factors are also provided in Table 20, representing the proportion of the common variance that each factor accounts for independent of the other. The Deep Approach factor is shown as making the greater contribution to the explained variance. Shown as well in Table 20 are final communality estimates for each variable, representing the total proportion of the variance of each subscale that can be predicted by the identified factors.

Limitations of the Study

In terms of possible threats to internal validity, we need to address the possibility of selection bias (Stanley & Campbell, 1963), since random assignment of individual subjects to conditions was not possible in this study due to the real-world constraints of the school setting. To the extent that evidence of random assignment is lacking, difficulties can arise in separating treatment effects from pre-existing differences between groups. However, the random assignment in this study of intact groups to conditions met the basic requirement outlined by Slavin (1984) for at least three classes to be assigned to each condition, thus serving to "reduce the possibility of false treatment effects" (p. 33). Testing statistically whether there are initial differences among groups helps us to further determine group equivalence (Moore, 1983, p. 171). According to Campbell and Stanley (1963, p. 48) the more similar the treatment and control groups are, the more effective the control group becomes. In this study the treatment and control groups were shown to be equivalent on the proportion of learners characterized as LPQ-Deep, a variable of central importance to this research. As noted previously, however, the use of this measure to establish group equivalence may be problematical due to the lack of strong empirical evidence confirming the relationship between LPQ scores and SOLO classifications.

CHAPTER FIVE

Discussion

In this chapter we will present a discussion of the results described in Chapter Four. After presenting the framework for our research in a brief overview, we will discuss findings relating to the individual hypotheses tested. We will also look at the overall implications of the study in an effort to set the research within a broader context.

Overview of the Study

Our research interest in this study can be broadly described as the exploration of the role of individual differences in the application of learning strategies. In this study the main issue of interest is the relationship between qualitative differences in students' approaches to study and qualitative differences in the associated learning outcomes.

The present study represents an attempt to develop greater understanding of how to help learners improve their ability to learn. We defined our primary goal at the outset in terms of improving the process of learning for the less skilled learner. We are first and foremost interested in helping these students develop effective learning strategies. At the same time, since we are interested in how individual differences interact with learning strategies, we are also concerned with the impact of learning new, competing strategies on the performance of skilled learners who already possess effective learning strategies.

This study specifically investigated the effect of instruction in cognitive mapping on Grade 8 and Grade 9 students, classified according to qualitative differences in their learning approach, to determine if applying a cognitive mapping strategy would have an effect on quality of learning outcome in a text comprehension task.

Qualitative differences in students' approaches to learning were determined by scores on the Learning Process Questionnaire (LPQ), a diagnostic instrument yielding a classification of students on deep and surface approaches to learning. The deep learning approach can be described in terms of the predisposition to derive meaning from study assignments and to do so through the linking of ideas and understanding relationships between them. The surface approach is characterized by the general tendency to demonstrate a reproduction orientation to achieve rote learning, relying mainly on memorization techniques. It was noted in Chapter 3 that to be classified as Deep, learners were required to score (a) above average on Deep Approach and (b) average or below average on Surface Approach. Likewise, to be classified as having a surface approach, learners must score (a) above average on Surface Approach and (b) average or below average on Deep Approach.

The ability to link ideas in a meaningful framework serves to distinguish the learner with a deep approach from the learner with a surface approach. We have applied this distinction here to differentiate skilled learners, that is, learners characterized by a deep approach, from less skilled learners, that is, learners characterized by a surface approach.

Qualitative differences in learning outcomes were determined by classifying responses to a text comprehension task (an essay test) as deep or surface using the Structure of Observed Learning Outcome (SOLO) Taxonomy. Our interest is in promoting meaningful learning, which we have defined as characterized by the building of connections between ideas, resulting in the construction of mental representations.

In this study we are specifically interested in investigating cognitive mapping as a strategy that less effective learners could acquire to ensure meaningful learning. The use of cognitive mapping strategies to improve learning has been demonstrated in a variety of contexts, including text comprehension. By being required to generate visual representations of the information presented in a text passage, the learner is forced to focus on the relationships between ideas in the text, linking ideas across the passage, and thus constructing a model of his or her interpretation of the content. Learners characterized by deep approaches appear to have such strategies occurring naturally, whereas learners classified as surface do not appear to be able to draw on such strategies. It was hoped in this study that the LPQ could serve to identify learners who could benefit from learning a specific cognitive mapping strategy and show evidence of increased meaningful learning from its application.

Discussion of Individual Hypotheses

Hypothesis 1. Students who apply a given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students who do not apply the strategy.

In support of this hypothesis, analysis of the results revealed that cognitive mapping instruction did in fact have a significant effect on the dependent measure, that is, the SOLO classification of responses. This finding provides support to the growing body of research related to cognitive mapping, including its application to text comprehension, that is providing increasing evidence of its effectiveness as a learning strategy. By requiring the learner to relate key concepts spatially in a visual representation, cognitive mapping strategies may provide a means of ensuring, in terms of specific tactics, that the learner builds a mental model of the content of a text passage.

The present study contributes to the body of research in cognitive mapping in its measurement of qualitative differences in learning outcome to substantiate its effectiveness as a learning strategy. Previous studies have generally relied on measures of quantitative differences in learning outcome, that is, "amount retained" (Mayer, 1979). In measuring meaningfu. learning, we require dependent measures that are sensitive to changes in the learners' processes and outomes (Mayer, 1988). The application of the SOLO taxonomy to assess learning outcomes as deep or surface represents a departure from previous practice by offering a means of evaluating the quality of student output in a systematic way. Assessing written learning outcomes in terms of evidence of the learner's having linked ideas, as specified in the SOLO Taxonomy, represents a relevant option for measuring meaningful learning.

Whereas claims have been made that mapping strategies are a "useful tool that could move students from learning by rote to learning meaningfully" (Novak, 1990), few attempts have been made to measure such progress on a *qualitative* basis as was done in this study. While previous research has generally shown that cognitive mapping strategies have been effective as measured by quantitative differences in learning outcome, this study demonstrates, arguably more importantly if meaningful learning is the desired goal, that a *qualitative* difference in outcome can be attained.

The present study also contributes to the research on cognitive mapping by providing evidence of the effectiveness of a strategy employing a simplified approach, requiring a less intense procedural focus than other mapping strategies aimed at acquiring knowledge from text. The resulting reduction of instruction time and task time without detracting from its benefit as a learning aid, can serve to increase the accessibility of such a strategy to students.

This study also serves to contribute to research and knowledge of cognitive mapping strategies in its examination of the impact of individual differences in learning new strategies. The interaction of learning approaches with cognitive mapping strategies, or learning strategies in general, for that matter, has received little attention in the research literature. The following hypotheses represent an attempt to investigate links between differences in learning approach and the effectiveness of applying a cognitive mapping strategy.

We should like to add a precautionary note in interpreting the results for Hypothesis 1. In the case of semirandomized experimental comparisons, as in the present study, any problems in establishing group equivalence implies that one should exercise care in attributing group differences entirely to the effect of the treatment. As pointed out in the "Results" chapter, the use of Biggs' LPQ to establish group equivalence may be considered to be problematical due to the lack of solid empirical support confirming its relationship to SOLO Taxonomy classifications.

Hypothesis 2. Students classified as having a deep approach to learning on the basis of their scores on Biggs' Learning Process Questionnaire (LPQ) will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students who are classified as having a surface approach.

Results of the analysis testing this hypothesis indicated that a larger proportion of SOLO-Deep responses was found in the group of students classified as LPQ-Deep than in the group of students classified as LPQ-Surface or LPQ-Neither Deep Nor Surface (LPQ-Neither). LPQ-Surface and LPQ-Neither students were combined into one group as recommended (Siegel, 1956) to facilitate the analysis described in Chapter 4. The results can be considered as providing weak support for the hypothesis as the incidence of SOLO-Deep responses in the LPQ-Deep group of learners was lower than we would have liked (only 2 out of the 9 responses were categorized as SOLO-Deep).

In attempting to understand this finding, it may be relevant to note that the LPQ was originally developed as a means to categorize students' approaches to study in general, and not necessarily to an individual learning task. Although, as we have noted in Chapter Two, there is a considerable body of research that supports the notion of stability of approach across tasks, we need to consider the influence of context on the choice of approach.

We know, on the basis of past research, that learners with a deep approach may choose to apply a surface approach based on their understanding of the context. For example, if students perceived the stimulus question in the study to be of a surface nature, then they may have chosen to apply a surface approach in responding to it. The requirement "to write what they learned from the article" may be interpreted as requiring a multi-structural or surface response rather than a relational or deep response. This perception would be particularly true of students who have been routinely reinforced for responding in a surface manner, a typical situation in many high schools. This type of perception should lead to a larger number of SOLO-Surface responses.

The implications are then that some of the LPQ-Deep students may have interpreted the context of the study as requiring a SOLO-Surface response, resulting in fewer SOLO-Deep responses. The desirability of a relational or "deep" response may need to be more specifically signalled in the test instructions in order to ensure the context is as unambiguous as possible. Also, in terms of context we need to consider that perhaps some students were not motivated to cooperate because of the lack of associated academic credit. It is possible, as well, that students were simply not interested in the topic of the text passage assigned in the test. Fransson (1977) demonstrated that students are more likely to use a shallow-level approach when the content of an article is not of interest to them.

In interpreting these results, it is also relevant to consider the validity of the instrument used to identify learners with a deep approach, that is, the LPQ. In examining the results of the factor analysis presented in Chapter Four, we see that deep and surface approaches were indeed identified as factors for our sample population, in confirmation of Biggs' model.It may, however, be important to consider the possibility that the LPQ and the SOLO Taxonomy are not in fact addressing the same theoretical construct. As noted previously, more research is required to confirm the actual relationship between LPQ scores and SOLO categorizations.

Hypothesis Three. Students classified as having a surface approach to learning on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses in a text comprehension task than students classified as having a surface approach and who do not apply the given strategy.

The results of the data analyses did not provide support for this hypothesis. The findings demonstrated that the proportion of students categorized as surface learners obtaining a SOLO-Deep classification of their responses did not differ significantly between the treatment and control groups. Application of a cognitive mapping strategy appears to have had no effect on learning outcome for this set of learners.

In explaining this lack of effect it is important to consider the fact that two 50-minute classroom sessions may not have been sufficient for these students to learn the cognitive mapping strategy and be able to apply it effectively. More time may be required before it is truly to be assimilated as a strategy. Some of the research in the area indicates that a greater length of time may be required for such learning to take place for students in general, without reference to learning approach (Holley & Dansereau, 1984; McKeachie, 1984).

Taking learning approach into consideration may present a further challenge. If surface learners are indeed predisposed to adopt a surface strategy in a learning task, then it is possible that instruction in a deep strategy may initially be resisted, with the interference serving to mitigate the effects of applying the strategy.

As Schmeck (1988) has recommended, we may need to exercise caution in dealing with less able learners: "The tactic may not fit with the individual's style to yield a unified learning outcome. The tactic may be dissonant . . . we may need to consider ways of modifying aspects of his or her shallow learning style" (p. 179). According to Biggs (1985), such strategies need to be embedded in personological roots to be effective; otherwise they are merely "short-term props to learning".

If we consider Gibbs' (1981) contention that it is important to shift the student's conception of learning in order to influence a surface learner to adopt a deep approach, then perhaps this task is more long-term and difficult. As Gibbs has noted, "Students' orientation and understanding of purpose are deep-rooted, fundamental aspects of their approach to learning tasks, which change slowly and with difficulty, and which can bring about disorienting consequences when they do develop and change" (p. 86).

Kember (1991) has confirmed the importance of first diagnosing conceptions of learning and has noted the possible difficulties involved in causing learners to alter deeply held conceptions. Kember and Gow (1989) have suggested that learners who do not apply deep strategies in situations where such strategies are clearly called for, may be individuals with an inadequate conception of learning, that is, they interpret the situation as calling for rote rather than meaningful learning.

If the individual's strategy reflects a deeply held conception of learning (e.g., learning is quantitative in nature), then it may be necessary to apply Lewin's three stage process for inducing change, as suggested by Kember (1991), to the current context. West (1988) has recommended the following procedure:

1. A process for diagnosing existing conceptual frameworks and revealing them to the student.

2. A period of disequilibrium and conceptual conflict which makes students dissatisfied with existing conceptions.

3. A reconstruction or reforming phase in which a new conceptual framework is formed.

Such a procedure, involving challenging firmly held conceptions, can be a time-consuming process (Kember, 1991).

Another possible explanation for the lack of support for this hypothesis involves perception of the learning task, which may play a role with this group of learners, namely surface learners who were in the treatment group. It is possible that surface learners will tend to interpret task instructions from a surface point-of-view. So even if they in fact had utilized a deep approach to the learning task, that is, the construction of a cognitive map, and had indeed constructed a "deep" mental model of what they had learned, they may not show evidence of this learning in their response to the question in the test situation. They may have perceived the question to require a surface level response, or the habit of responding using a surface approach may be too strong for these learners to overcome within the given time-frame.

It is also possible that further instruction may be required in framing deep responses; this group of learners may lack the writing skills required to integrate ideas in a relational manner. The skills learned in creating a cognitive map may indeed result in the development of a mental model of the text studied, however, this does not necessarily mean the student can now express the mental model in essay format. An additional set of skills may be required in the writing of SOLO-Deep responses.

Again, it is possible, as discussed in the explanation of Hypothesis 2, that students may simply not have been interested in the topic of the text passage assigned in the test and thus may have been more likely to produce a surface learning outcome, as demonstrated by Fransson (1977).

Hypothesis 4. Students classified as having a deep approach on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate less evidence of SOLO-Deep responses in a text comprehension task than students classified as having a deep approach and who do not apply the given strategy.

The results from the data analysis did not support this hypothesis; there was no significant difference between the two groups in terms of the proportion of learners who scored SOLO-Deep responses. The learning of the cognitive mapping strategy therefore did not appear to interfere with performance on the text comprehension task.

In explanation it may be that learners characterized by a deep approach are able to assimilate different deep strategies. The lack of interference may be attributed to the fact that the goal of a deep approach in general is to facilitate the linking of ideas and the understanding of relations. Learning a different tactic for achieving the same outcome, that is, meaningful learning, may simply result in the option of selecting an alternate, interchangeable tactic for the same strategy, and thus not represent a conflict.

In interpreting the results of testing both Hypothesis 3 and Hypothesis 4, wherein the cognitive mapping treatment was found to have no effect on either the learners classified as LPQ-Surface or LPQ-Deep, it is important to consider several possibilities. First, we should question the assumptions underlying these hypotheses; it is possible that learners characterized as having either a surface or deep approach to learning are not in fact differentially affected by the application of the cognitive mapping strategy. We would thus, in effect, be questioning the impact of individual differences in this regard.

Alternatively, we may question the validity of Biggs' deep and surface factors for the sample population utilized in our study. As noted earlier in this chapter, the factor analysis indeed strongly supported the validity of these factors for the sample. The latent variables identified were clearly congruent with Biggs' factor structure.

As a further point we may question the use of the LPQ to operationalize the terms "surface approach to learning" and "deep approach to learning". It is possible that the questionnaire does not in fact properly differentiate between surface and deep approaches as defined by Marton

(1975). Additional empirical support confirming such a connection would be warranted.

Yet another option in interpreting the lack of a treatment effect for learners categorized as having deep or surface approaches involves the actual experimental design. It is possible that the design itself precluded the detection of diffences due to the small size of the samples compared. A larger sample may have yielded different results.

Expanded Analysis

If we operate under the assumption that the LPQ does, in fact, differentiate between learners with surface and deep approaches, then the following expanded analysis is of interest. The lack of a treatment effect for these two groups of learners is then especially interesting in light of the evidence of an effect when the entire sample of 118 students, including the larger group of learners classified as not having a dominant learning approach, is taken into consideration. These results le. to additional analysis of the data from the remaining learners classified as not having a dominant learning approach.

Our original concern in formulating the overall focus for the current study was to teach less able learners strategies to improve their process of learning. The surface and deep distinctions were chosen as the source of individual differences, with the deep learning approach representing effective learning insofar as deep strategies lead to meaningful understanding in a learning task. The surface approach to learning was seen as a strategy of a less effective learner as it was characterized by rote learning and a reproduction orientation.

It is possible, however, as we suggested earlier, to classify the learner who does not have a dominant approach to learning as another case of a less skilled learner, insofar as we have categorized only those learners characterized by a deep learning approach as skilled learners. The learners classified as not having a dominant approach scored only average or below average on the LPQ Deep Approach scale.

In an expanded analysis, Hypothesis 3 was re-analyzed, and the group of learners categorized as LPQ-Surface was replaced with the group of learners categorized as not having a dominant learning approach to represent a category of less skilled learner.

Extended Hypothesis 3. Students classified as not having a predominant approach to learning on the basis of their scores on Biggs' LPQ and who apply the given cognitive mapping strategy when reading a text passage will demonstrate greater evidence of SOLO-Deep responses to a text comprehension task than students classified as not having a predominant approach and who do not apply the given strategy.

Analysis of the data did in fact provide support for this hypothesis. The findings demonstrated that the application of a cognitive mapping strategy did have a significant effect on learning outcome. Students who did not have a dominant approach to learning, as measured by the LPQ, thus were able to benefit from applying a deep strategy.

The interesting question to address is why the treatment had an effect on this classification of learner and not on the learner categorized as having a surface approach. The possibility must be examined that the lack of a predisposition for a type of learning approach may result in a more receptive learner or may otherwise facilitate the learning of a new learning strategy. It is likely that these learners did not find the new technique interfering with their normal routine or conflicting with their conception of learning, thus resulting in improved performance on the text comprehension task.

At the same time we may entertain the notion that learners with a predominant approach, that is, those classified as LPQ-Surface or LPQ-Deep, may share a characteristic, perhaps even unrelated to the surface-deep distinction we have drawn in this study, that serves to interfere in their receiving benefit from the cognitive mapping strategy.

The finding that the treatment had a significant effect on learners without a predominant approach to learning could have useful implications in terms of practical value to teachers. These learners represent a much larger group in this study than the group categorized as having a surface approach, and may well be representative of the "average learner".

According to Biehler & Snowman (1993), most students are inefficient learners:

> Their attempts at encoding rarely go beyond rote rehearsal (for example, rereading a textbook chapter) simple organizational schemes (outlining), and various cuing devices (underlining or highlighting). When the nature of the learning task changes, few students think about changing their encoding techniques accordingly. . . . One reason for this state of affairs is that students are rarely taught how to make the most of their cognitive abilities. (p. 392)

Vaughan (1984) pointed out that most students routinely perceive themselves to be the problem when experiencing difficulties in comprehending text:

> Few students realize[d] . . . the relationship between new learnings and prior understandings. Nor do they realize they can manipulate and structure conceptual relationships, much less how to do so. (p. 129)

Most of these learners are not even aware of alternate strategies. Teaching these students cognitive mapping may well provide them with such alternatives, opening the door to expanding their potential for meaningful learning.

Conclusions

In general we may say that the study demonstrated that the application of a cognitive mapping strategy can bring about a *qualitative* change in learning outcome. The results of the study appear to indicate that cognitive mapping can be an effective strategy for many students in deriving more meaningful learning from a study task. Given that 33% of the treatment group attained SOLO-Deep scores versus 6% in the control group, this strategy can be regarded as an important tool.

The possibility of using such techniques to improve the effectiveness of learners in a relatively short time (two fifty-minute instructional periods) should be of great potential interest in terms of practical application.

Our results also suggested that individual differences may play a role in determining the effectiveness of applying the cognitive mapping strategy. As classified on the basis of Biggs' Learning Process Questionnaire, students with surface approaches appeared to receive little benefit from applying the strategy, signalling the need for a different type of intervention, or perhaps more intense training in the same strategy. In considering the students classified as having deep approaches, it appears that the application of a cognitive mapping strategy did not have a negative impact as predicted. The needs of both of these groups need to be considered separately to maximize the effectiveness of instruction in learning strategies.

What is most interesting is that our research reveals that a large group of learners, who are not categorized as either deep or surface on the basis of the LPQ, did appear to benefit from applying the cognitive mapping strategy. It seems that this group, with relatively minor instructional effort in the teaching of cognitive mapping, can be set on the path of meaningful learning.

Taken as a whole, our findings with respect to the role of individual differences point to the need to take such differences into account when trying to address training in learning strategies. The implications of these findings are significant, especially when taking into consideration Corno and Snow's (1986) recommendation that: "The majority of students will need more aptitude support than conventional teaching provides, and different kinds of specialized support will likely be needed for different kinds of students" (p. 625). We recommend techniques which focus on development of the individual learner.

The results of our investigating the role of individual differences in the effectiveness of applying a cognitive mapping strategy are less unequivocal than we would like. In view of our findings, we would like to see a stronger link between learning approach and quality of learning outcome to clarify the validity of the instrument used to classify students on approach to learning, namely Biggs' Learning Process Questionnaire. We require additional clarity with regard to any differences between the constructs actually measured on the LPQ and the constructs we would like to see measured. Tools for assessing individual differences such as learning approach need to be subjected to additional validation testing for future research. We may conclude that investigating the interaction of learning approach with learning strategies is a complex matter, subject to all the problems inherent in testing a traitlike attribute, for example, cognitive style.

It would be helpful to determine if when we are measuring deep and surface approaches to learning, we are measuring a single, bipolar construct with extreme opposites at either end or are we measuring both approaches on a continuum, which any learner may have the potential to develop, or are they in fact two orthogonal constructs. This leads us in the direction of choosing "versatility" in approach as a goal for student learning, as described by Pask (1988), or a "synthetic style", as described by Kirby (1988). We need to determine how various measures of learning approach compare in the assessment of such an approach.

In summary, we may say that the current study contributes to research in the field of educational technology by:

i) contributing to the research base in cognitive mapping strategies by:

   a) applying measures of qualitative differences to learning outcomes, and

   b) addressing the issue of individual learning differences.

ii) contributing to the research base on learning approach differences by:

   a) providing evidence of differences in learning outcome,

   b) suggesting that a group of students, here defined as learners without a predominant learning approach, may present considerable potential for application of learning strategy research, and

   c) heightening sensitivity to the possibility that students may be receptive to different tactics with regard to learning new strategies on the basis of differences in learning approach.

Limitations of the Research

In terms of internal validity, we need to acknowledge the possible threat concerning the lack of random assignment of individuals to groups. The use of intact classes represented a real-world constraint in the present study. Although the random assignment of three classes to each condition met Slavin's (1984) minimum requirements for the use of intact groups (p. 33), we recognize this situation to be less than ideal. We understand random assignment to different treatment groups to be one of the most important features of the ideal experimental design and recognize the importance of dealing with the problems of nonrandom assignment. In particular, we understand the need to exercise caution in attributing significant differences in results to treatment effects.

In addressing external validity, it is necessary to consider the degree to which findings can be generalized to a larger population. In terms of population validity, we see no serious concern as the high school students participating in the study span a range of socioeconomic classes and ethnic groups, ensuring generalizability to other North American classrooms with such characteristics.

Future Research Implications

Based on the results obtained in this research, a number of recommendations, outlined below, can be made regarding possibilities for further study. First of all, it would be of interest to replicate the current study while addressing (a) the issue of group equivalence by applying the use of appropriate covariate measures and (b) the issue of the small size of the groups of students actually designated as having deep and surface approaches by increasing the total sample size.

Also in terms of the study itself, it would be interesting to clarify the role of student motivation in this type of research. For example, the fact that students knew that they would not be graded on their work may well have influenced their participation. The study could be repeated providing a context to help ensure motivated participation.

Also of interest would be repeating this research with more stringent measures to address another issue related to context, that is, ensuring clarity with regard to test instructions. In interpreting the results of the current study, we were unsure to what degree context in general played for students characterized as having a deep approach to learning, since these students can exercise a choice in applying either a surface or deep approach. Providing test directions which clearly signal the appropriateness of a deep response may serve to clarify the context for these students.

In terms of other key recommendations, we would like to see further research in determining more specifically the role of individual differences on the impact of the application of learning strategies such as cognitive mapping. We need additional definition related to the constructs of deep and surface approaches to learning, and especially how they can be assessed without the laborious method used by Marton et al. (e.g., Marton & Saljö, 1976) and perhaps with a better measure than Biggs' LPQ.

Validating the LPQ with Marton's phenomenographical approach in which personal interviews on learning approach are conducted with learners who complete Biggs' questionnaire would be of great interest. As well, investigation of the relationship between the LPQ and the

SOLO Taxonomy is important in determining the connection to Marton's interpretation of the constructs of deep and surface approaches to learning. At present it would appear that SOLO-Deep may be an outcome of Marton's deep approach to learning; further research is required to investigate this possibility.

Further research is required to determine if other tools assessing surface and deep approaches, such as the high school version of Entwistle's (Entwistle et al., 1979) Approaches to Studying Inventory (ASI), can more effectively predict a deep learning outcome in high students. It would be of value to determine to what degree Biggs' LPQ and Entwistle's ASI are indeed measuring the same constructs. As well, it would be worthwhile to determine the correlation among similar measures designed for university level students, such as Biggs' (1978, 1979, 1987a) Study Processes Questionnaire (SPQ), Entwistle's (Entwistle et al., 1979) Approaches to Studying Inventory (ASI), and Schmeck's (Schmeck et al.,1977) Inventory of Learning Processes (ILP). In general, although some information is available, a gap exists in the research literature in describing how the various means of assessing learning styles and approaches relate to each other, and the degree to which they are measuring the same characteristics.

This study appears to demonstrate that learners who do not have a dominant learning approach, as defined by use of the LPQ in this study, can apply the cognitive mapping strategy to a particular learning task and achieve a deep learning outcome. We would like to determine whether any of the learners who have applied the strategy in the experiment under test conditions continue to apply the strategy in other situations; that is, is there any transfer of learning to other school or non-school situations? Research is necessary to determine if it is possible for these learners to generalize this strategy to other learning tasks and to determine if in fact a long-term change in learning approach can take place.

The present research investigates effects on immediate learning outcomes. It would be useful to test stability of change in outcome over time, that is, to determine whether there would be retention of meaningful learning over time for those learners in the experimental group who applied the new cognitive mapping strategy and who demonstrated evidence of meaningful learning in their responses.

The study was limited to grade 8 and 9 students; research should be conducted to see if similar results could be attained in earlier grades, or in later grades, as well as by post-secondary students.

It is important to further explore the possibility of effecting a change in learners characterized by a surface approach, whom we initially targetted as representing ineffective learners. We would like to determine if a more extended treatment of the same kind used in this study (i.e., an increased number of instructional sessions on cognitive mapping with additional opportunities for practice and feedback on performance) could improve the ability of these learners to learn meaningfully, or do they require other types of interventions. In general, we need to determine how best to address the issue of modifiability for this type of learner. Specifically, we may need to determine methods for addressing personological variables, as suggested by Biggs (1985), and conceptions of learning as suggested by Gibbs (1981) and Kember and Gow (1989). Alternatively, instructional designers may be able to modify their products with respect to this type of learner.

Given that there is evidence that learners with certain approaches to learning are able to benefit from instruction in cognitive mapping as one type of deep strategy, it seems worthwhile to explore the potential of other deep strategies in effecting such change. It may be that other such strategies or another combination of strategies could be more effective in helping students derive more meaning from their learning tasks. Research is required to determine what these strategies are and how they could best be applied.

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Appendix A

Text Passage Used in Phase 3 (Testing Session)

DISCOVERIES IN INNER SPACE - YOUR BRAIN

It used to be an often quoted statistic that we only use 10 percent of our potential brain power. The more psychologists have learned in the last ten years however, the less likely they are to dare to attempt to quantify our brain potential. The only consistent conclusion is that the proportion of our potential brain power that we use is probably nearer 4 percent than 10 percent.

Most of us, then, appear to allow 96 percent of our mental potential lie unused. But it doesn't have to be so. Once we begin to understand how the brain works, the way is opened to tap that vast unused potential.

Let us first look at how the brain develops. The human nervous system, controlled by the brain, begins its development only 20 days after conception. Five weeks from conception brain development starts in earnest and after eight weeks the first of two brain spurts begins. At this stage the brain represents half the total length of the fetus (although it is still only 1/2 inch long!). This is when the neuroblasts begin to grow. Neuroblasts are embryonic cells that will in turn become neurons, or brain nerve cells. The speed at which neuroblasts are now developing is staggering. They are added at the rate of several thousand a minute.

Twelve weeks after conception, the tiny fetus is now adding neurons at the rate of 2,000 a second. To put this into context, an adult honeybee's brain contains some 7,000 neurons. A bee can accomplish many sophisticated tasks, including building and maintaining a honeycomb, calculating distance, signaling to its companions the direction of pollen sources, and recognizing a course by sight and smell—all with the number of neurons the human fetus develops in under three seconds. About 20 weeks after conception or 18 weeks before birth, the human embryo has laid down its entire nervous system: 12 to 15 billion neurons.

While the number of neurons is important, of even greater significance is the next stage of brain development: the second brain spurt. About ten weeks before birth, each neuron starts to send out numerous thin fibers to make actual and potential connections with other neurons.

The power of the brain is largely a function of the *number* of neurons and the *richness* of their connections. The capacity of the human brain can be expressed in the number of connections of which it is capable. Since each neuron can itself make thousands of connections, the potential number of interconnections in the brain runs into trillions. Our brains are actually capable of making more patterned interconnections than there are atoms in the universe.

Only some of these connections, however, are made automatically. The key thing to remember is that most are made by *using* the brain. The more the brain is stimulated, the richer the connections and the higher the practical mental ability.

The way in which the brain actually develops enables us to dispose of the question of whether intelligence is a function of heredity (nature) or environment (nurture). The answer is both. The number of brain cells is a factor, but the way those brain cells are stimulated to make rich connections is far more significant. Thus it is probably correct to say that almost every child is born a potential genius.

Even if innate intelligence is merely average, a rich intellectual environment during the period of the second brain growth spurt, with plenty of opportunities to learn, can ensure the development of a greater proportion of the brain potential than would normally be expected.

We have seen how the number of neurons in the brain is fixed before birth. Unlike any other body cells, brain cells do not usually regenerate themselves. However, even if they did die at the rate of several thousand a day, the loss over a lifetime would be trivial and quite unlikely to affect practical mental ability. Of far greater significance is the fact that the number of connections between neurons is continuously growing, and this would more than compensate. In fact, it would argue for an improvement of mental ability with age.

So far we have been speaking of "the neuron". This gives a misleading picture of simplicity. In fact, the neuron consists of a cell body (the gray matter) from which leads a principal fiber called the axon. The axon is covered by a fatty coating called myelin and it may terminate either in a connection with another neuron cell or with branchlike fibers called dendrites. The axon and dendrites are the white matter of the brain.

To oversimplify, the axon transmits the electrical impulses that mark the working of the brain; the dendrites receive them. Gluing the whole brain together and nourishing it are glia cells (from the Greek *glia*, meaning "glue"). If you were somewhat surprised by the numbers involved in 15 billion brain cells and were astonished that there are hundreds of times more dendrites, you may choose not even to try to comprehend the fact that there are probably 100 billion glia cells in the human brain.

The junction at which two nerve cells meet, or at which dendrite meets dendrite, is called the synapse. This is a tiny gap, and the electrical activity of the brain is conducted down the axon to the synapse. A connection is made when one of a number of chemicals is released to bridge the gap at the synapse. These chemicals are called neurotransmitters and they permit electrical activity to flow across the synapse. The speed of transmission of a neurological impulse is about 100 meters a second. The *transmission* of brain activity, then, is not electrical, but a physical/chemical reaction to an original electrical impulse. Mental activity involves complicated physiochemical activity. In fact, Dr. David Samuels of the Weizmann Institute estimates that there may well be up to a million chemical reactions taking place in the brain in any one minute!

We now know that there are up to 30 different types of neurotransmitter. Some are amines, most are amino acids, the building blocks of protein. We also know that neurotransmitters not only transmit an impulse but are capable of modifying it along the way, although we do not yet know how. When we do, we may begin to unlock the physical secrets of memory and thought. That will be a break- through comparable to the initial cracking of the double helix genetic code by Crick and Watson.

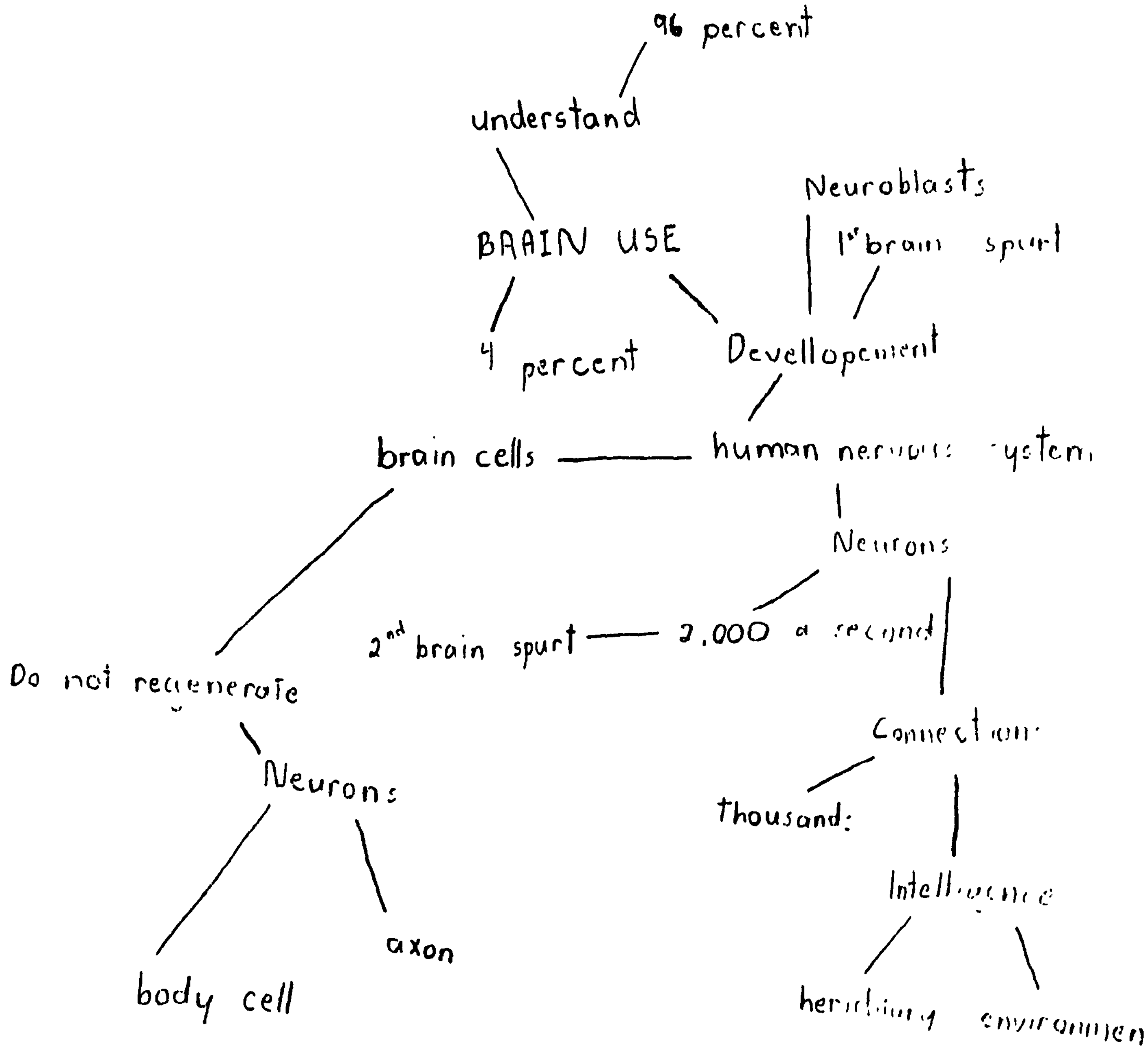
The brain is the only organ that expands through use. The more it is used, either to acquire facts or in the process of creativity, the more memory associations are formed. The more associations are formed, the easier it is to remember previously acquired information and also to form new associations, i.e., create new ideas and concepts.

The fundamental determinant of the brain's potential is the number of connections it can make. With 10 to 15 billion nerve cells, each one capable of making thousands of contacts, the possible permutations of connections runs into the trillions. Yet this massive brain potential was acquired not by astronaut man but by Neanderthal man, because the three-pound human brain has not physically changed much in the last 50,000 years.

In terms of the brain's potential, Dr. Frederic Tilney, a leading French brain specialist, stated that "We will evolve cerebral centers which will permit us to use powers that we are now not even capable of imagining."

Appendix B

Examples of Maps Obtained in Phase 3 (Testing Session) from Students in Treatment Condition


96 percent
understand
BRAIN USE
Neuroblasts
1st brain spurt
4 percent
Devellopement
brain cells
human nervous system
Neurons
2nd brain spurt
2,000 a second
Do not regenerate
Neurons
Connections
thousands
Intelligence
body cell
axon
environment

YOUR BRAIN

brain spurts

neuro blasts

cell blasts

embryonic cells

neurons (brain nerve cells)

nervous system: 12 to 15 billion neurons

second brain spurt

rich intellectual enviroment

thin fibers

connections with other neurons

made by using the brain

potential brain power

10%

[illegible]

90% unused

central nervous system

development

20 days after conception

Nervous system laid down after 20 weeks of conception (12-15 billion neurons)

Ten weeks to build, neurons make contact with other neurons

twelve weeks after conception, 2000 neurons a second

several thousand added per minute

Resembles capacity of a bee

Neuroblasts begin to grow (brain nerve cells)

Brain Development starts 5 weeks after conception

Develops 20 Days After Conception

4% Used

Nervous System

Brain

96% Unused

Brain spurts start 8 weeks after conception

Opens Up To Use Unused Potential

Brain power depends on the number of neurons and the richness of their connections

Develops through heredity and environment.

The more the brain is stimulated, the richer the connections are and the higher the practical mental ability.

interconnections of brain

- more than atoms in universe
- power of brain
- nerons
- large capacity
- brain makes thousands
- tremendous potential
- trillions of them
- brain very capable
- some made automatically
- most made by using the brain

human develops in sophisticated neurons

1/sec.

12 weeks 12,000 neurons

2,000/min

honey bee

7,000 in all

4%, 96% unused
- used

more used the richer the connections

expands

expounds

only one

BRAIN

heredity

represents half of fetus at 8 weeks

every child born potential genius

Nervous system develops 20 days after conception

first brain

10 weeks before birth 2 brain

send out fibers

connections

many thousand neuroblasts a minute

early neurons

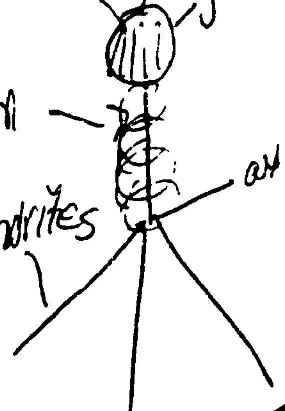
environment

number of nureons and richness

synaps

cell body

gray



myelin

axon

dendrites

gloed with glia cells

bridge

synapse

block

released

do not regenerate

chemicals

transmission

neurotransmitters

Brain

principle fibre is called axon. It is covered ~~by~~ by a fatty coating called myelin.

controlls human nervous system develops 20 days after conception.

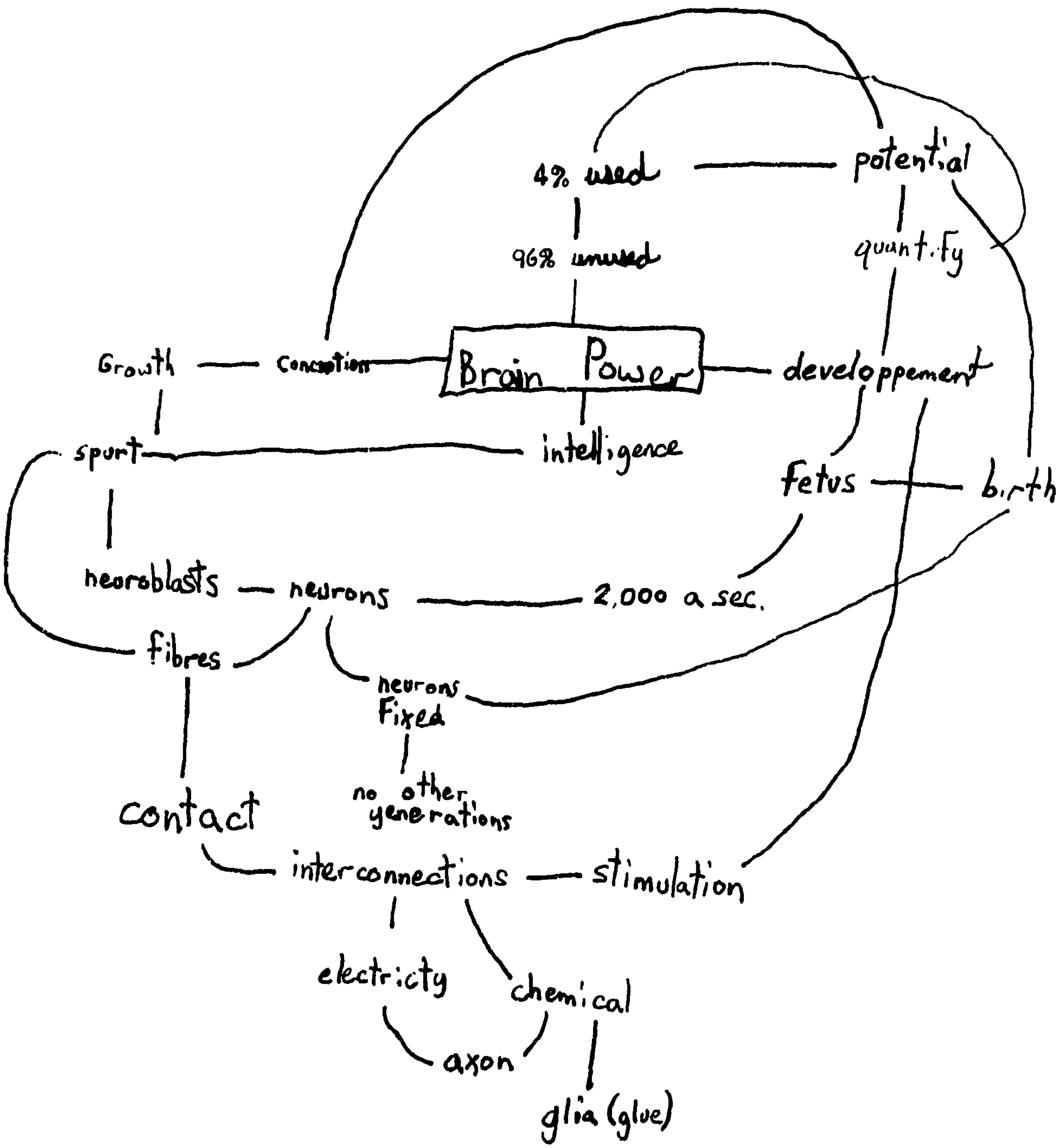
dendrites are branchlike fibres.

neuroblasts. are embroblasts cells that will in turn become neurons or brain cells.

The junction at which two nerve cells meet is called synapse.

The brain is the only organ that expands through use.

96% of our mental potential lie unused.


4% ~~used~~
96% ~~unused~~
potential
quantify
Growth
Conception
Brain Power
developpement
sport
intelligence
fetus
birth
neoroblasts
neurons
2,000 a sec.
fibres
neurons Fixed
no other generations
contact
interconnections
stimulation
electricty
chemical
axon
glia (glue)

BRAIN POWER

ONLY 4% USED

UNUSED POTENTIAL

UNDERSTAND HOW THE BRAIN WORKS

NERVOUS SYSTEM

DEVELOPMENT

Neuroblasts

Embryonic cells

2000 /s.

be only 7000 in all

BRAIN SPURTS

12 to 15 billion neurons

2nd Brain spurt

sends out thin fibres to make connections

POWER OF THE BRAIN

depends on the richness of the connections

made by using the brain

higher practical mental ability

richer

stimulated

INTELLIGENCE: Nature or Nurture

partially number of brain cells a factor

mainly stimulation

Almost every child is born a potential genius

Appendix C

Sample of Essay Question Used in Phase 3 (Testing Session)

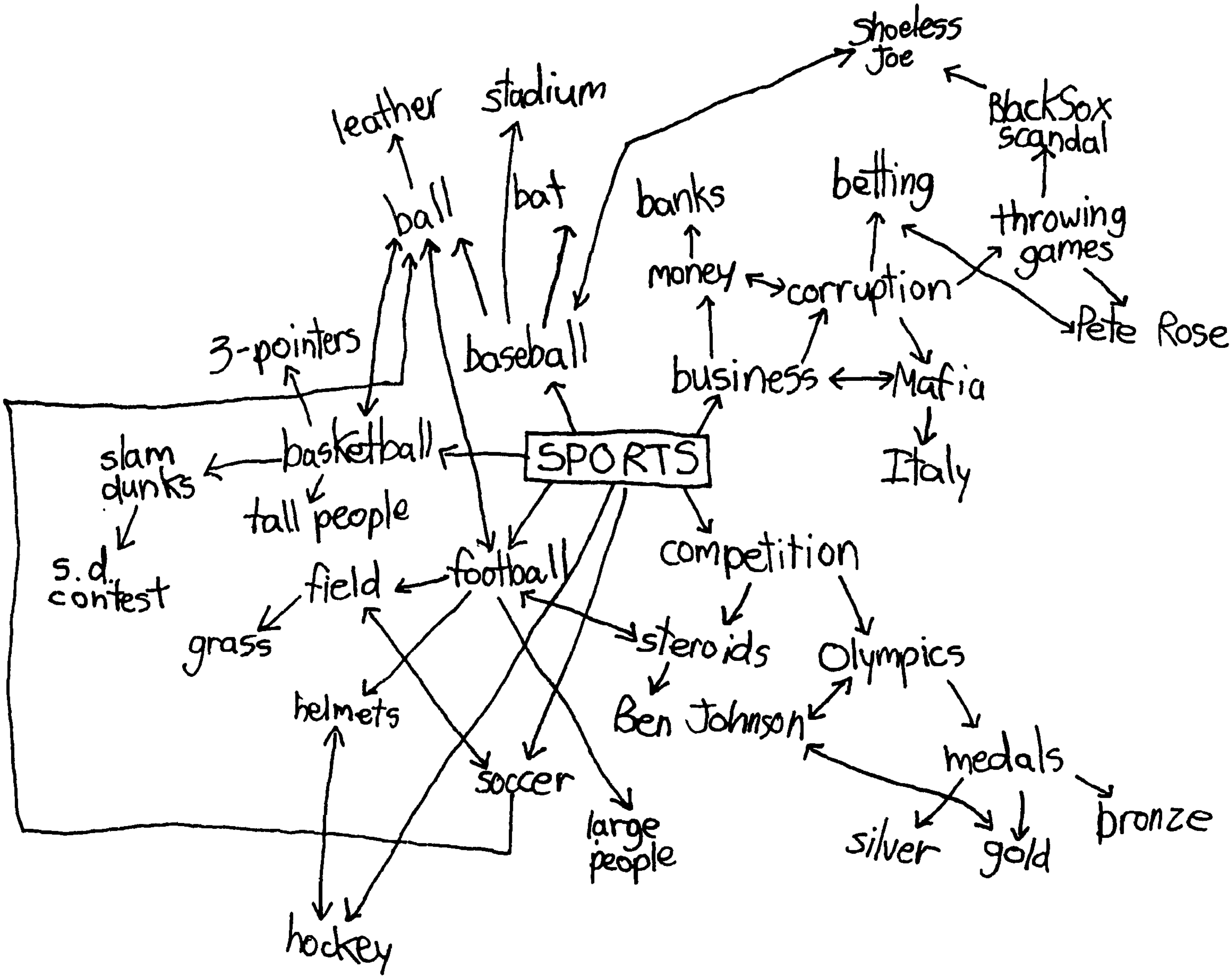
Name: ______________________________ Date: ________________

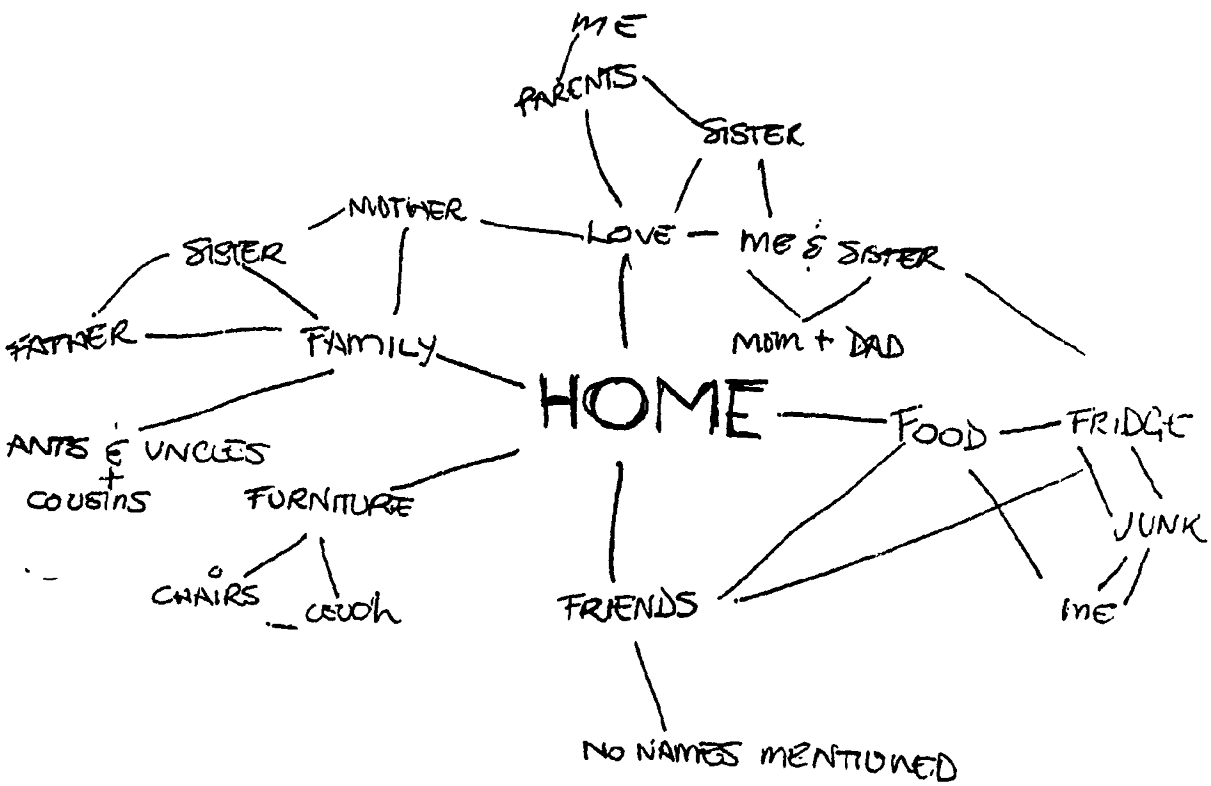
INSTRUCTIONS:
Write down what you have learned from the article. Imagine you were going to describe what the article was about to someone who has not read it. What would you say?

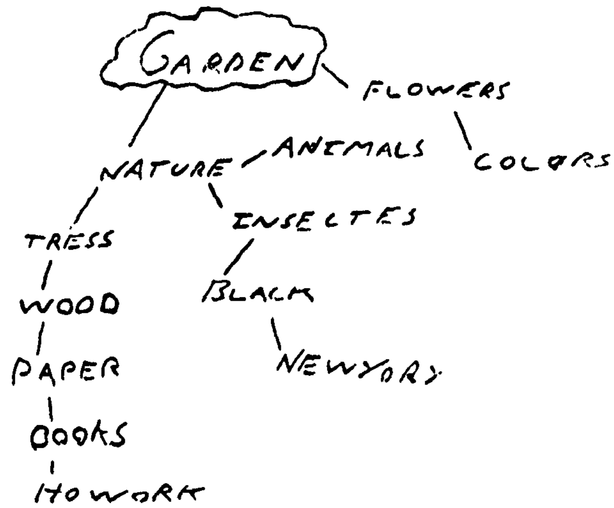
Appendix D

Examples of Maps Collected from First Mapping Exercise in Phase 2 (Instructional Treatment-Part 1)

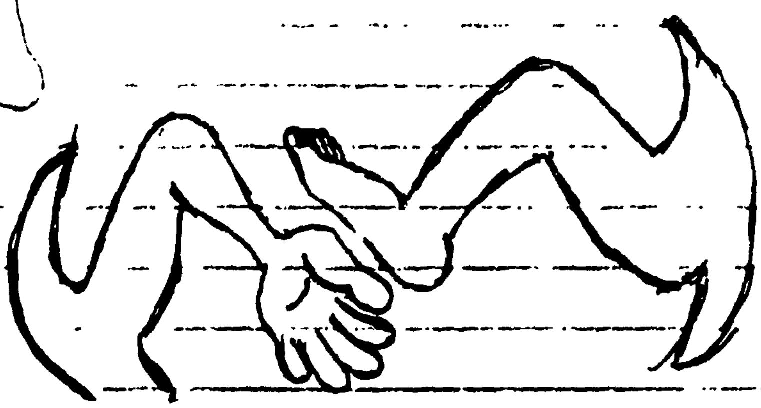
IDEA MAPPING

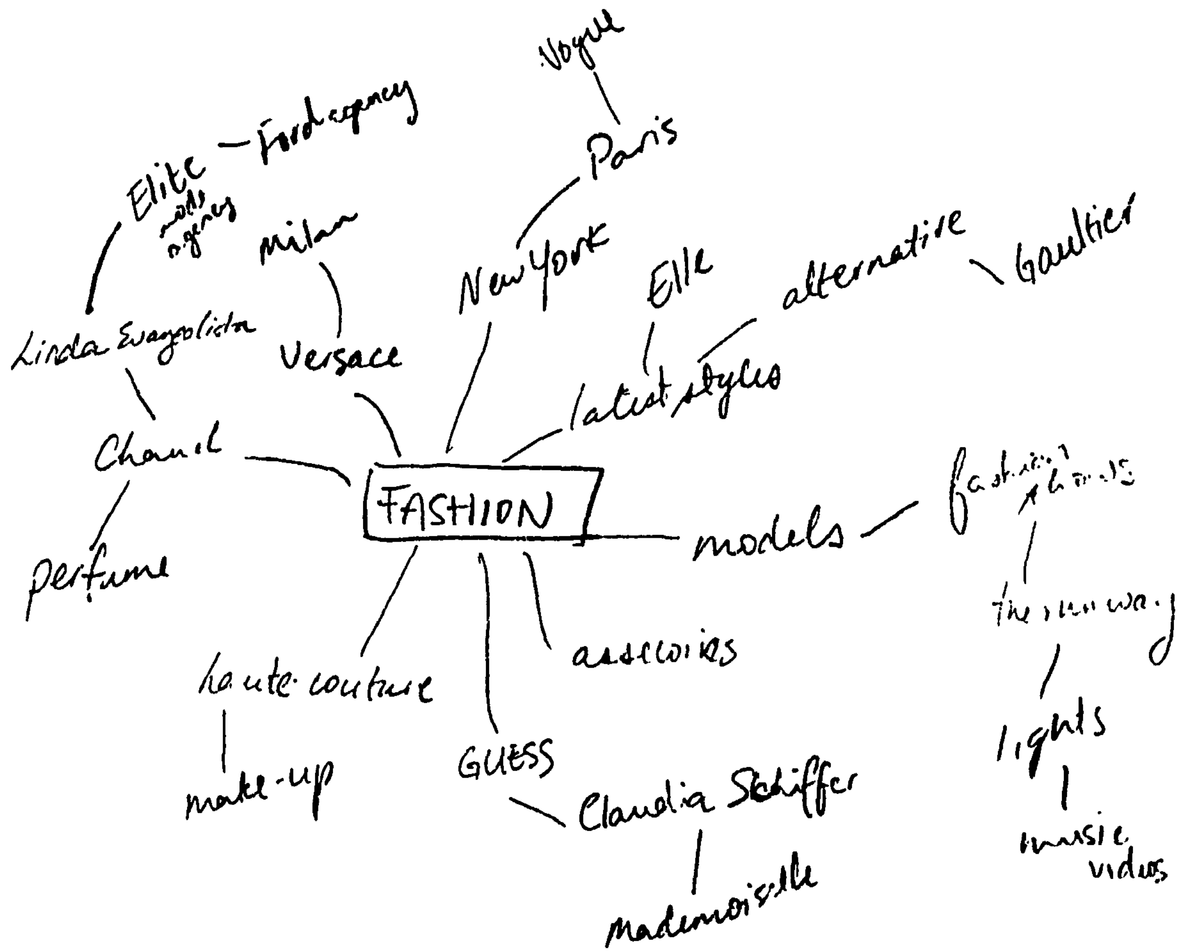



ME
PARENTS
SISTER
MOTHER
LOVE
ME & SISTER
SISTER
FATHER
FAMILY
MOM + DAD
HOME
FOOD
FRIDGE
ANTS & UNCLES
+ COUSINS
FURNITURE
JUNK
CHAIRS
COUCH
FRIENDS
ME
NO NAMES MENTIONED


GARDEN
FLOWERS
COLORS
NATURE
ANIMALS
INSECTES
TRESS
WOOD
BLACK
NEWYORK
PAPER
BOOKS
HOWORK

tug of war
Jogging
Play fighting
frisbee
entertain-ing
fiery
affectionate
Exercise
WATER
canned
Pets
food
dry
had 2
Dogs
Breed
habitat
back yard
Apartment
collie
~~coc~~ cocker spaniel
house
farm
Lots of space to run and frolic





Vogue
Paris
Elite model agency
Ford agency
Milan
New York
Elle
alternative
Gaultier
Linda Evangelista
Versace
latest styles
Chanel
FASHION
models
fashion shows
perfume
the runway
accessoires
haute couture
lights
make-up
GUESS
Claudia Schiffer
music videos
mademoiselle

Appendix E

Sample of Mapping Exercise Conducted in Classroom During Phase 2 (Instructional Treatment-Part 1)

Idea maps are tremendously effective as memory aids because they utilize a large number of the factors critical to learning and memory.

In constructing an idea map, you have to think about the information and decide what is significant. You simplify what you have heard or read, boiling it down into a few keywords or phrases that elegantly express the main points. You interact with the information. This is different from, for example, passive note taking in a class, where you often just try to copy down as many of the words as possible. You are also involved because you do something creative as you plan and draw the map.

The information in your idea map becomes encoded in your neuronal circuitry effectively because you are writing as you are hearing or reading, and are using imagery, as well as thinking about the material.

Creating an idea map forces you to organize the material in a clear visual pattern that shows the relationship of the various points to each other and to the central theme. This process both tests and reinforces your comprehension. Personally organizing information has been shown to be a powerful aid to understanding and memory.

As you may know, the brain works largely through association, connecting ideas in a nonlinear fashion. Idea maps use this same structure of association and therefore mimic how the brain works. Ideas that are closely related are linked together, reinforcing the association. This makes the idea map a powerful means of embedding knowledge in memory in a form that will make it easy to retrieve later.

Idea maps contain only a few keywords. These are the words of most significance and power, the concrete words that carry the essence of the communication and generate vivid imagery. They are usually nouns and verbs. Again, we do not remember complete sentences but ideas, and it is deas that are represented by keywords.

Since visual imagery is recalled much more perfectly than words, idea maps by nature are excellent memory stimulators.

Idea maps combine the left brain's verbal, analytic, and orderly proclivities with the right brain's inclination for spatial design, visual sense, and artistic sensibility. The typical outline form of note taking and planning generally serves only the left brain's style.

I. Topic
A. Subtopic
1. Related idea
a. Subsidiary idea
B. Subtopic

The more free-flowing form of the idea map, while still highly organized and intelligently condensed, also utilizes artistic and associational, intuitive abilities. This creative aspect and the use of graphics enhance your memory in "themselves" and they also encourage your active involvement in the process of distilling the essence of the information and depicting it in a concise and memorable fashion. Therefore, let your creativity flow! The more attention you lavish on your idea map, the better you will recall the material.

The most obvious use of idea maps is for taking original notes on books, articles, lectures, and meetings. In addition, you can use them to retrieve stored information from time to time. In studying for an exam, preparing to deliver a talk, and any time you need a review of information, a glance at an idea map gives you a quick capsule of all the essential points in just a few seconds—far less time than reading through paragraphs or pages of notes.

Appendix F

Sample of Article Provided for Homework Assignment in Phase 2 (Instructional Treatment-Part 1)

An Impossible Dream Realised

Edward Hughes confounded his teachers and gained spectacular results after following a study plan outlined in *Use Your Head*

EDWARD Hughes was 15 and a "fairly average student" when he was introduced to the book *Use Your Head.* His teachers described Edward as "in the middle of his class basically, not doing particularly well in any subject".

A short while earlier he had taken his school-leaving examinations. His results, as expected, had been C's and B's. He was particularly disappointed because he had wanted to go to Cambridge University and he realised that if he continued academically the way he was, he "didn't stand a chance".

It was then that Edward's father, George, introduced him to the book *Use Your Head* by Tony Buzan. Armed with new information about himself and about how to Mind Map in order to study better, Edward went back to school revitalised. He announced that he was going for A's in all his subjects, and that he definitely wanted to apply to Cambridge.

His teachers expressed their misgivings. "You can't be serious: come on, you've got no chance —your academic results have never been anywhere near the standard which Cambridge requires," said one.

"Don't be crazy! You could possibly get a B, but you'll probably get a C," said the second. When Edward said he wished to take not only the standard exam, but also to write the scholarship paper, the principal said flatly, "No, it's a waste of the school's money and your time entering for that exam. We don't think you'll pass. The exams are very, very difficult - we don't even get many passes from our best candidates."

After Edward persisted, the school was willing to allow him to apply, but he had to pay his own $50 entrance fee in order not to "waste the school's money".

The third teacher said he had been teaching the same subject for the past 12 years, and that as an expert in the area, he knew what he was talking about when he said that Edward would only get a B or a C. The teacher named "another chap" who was a much better student than Edward, and said that Edward would never be as good as this other "chap".

The fourth teacher chuckled, said he obviously admired Edward's ambition, and that Edward's dream was possible but unlikely. According to this teacher, even if he worked, Edward would only get a B. The teacher wished him luck, however, and said he always liked people who showed initiative.

To each of the teachers, and to anyone who questioned his goals, Edward's response was always firm and polite: "I'm going to get an A". The school officials initially did not want to allow Edward to take the exams. But after a while they agreed to do so, letting Cambridge know that they didn't think that this particular student was likely to get the place for which he applied.

The next and immediate stage was the college interviews. At these, the Cambridge professors informed Edward of his school's opinion of him, agreeing with the school that his probability of success was very low. They told him they admired his initiative and that he'd need at least two B's and an A, but more probably two A's and a B, or three A's, and wished him luck

Still undaunted, Edward pursued a study plan outlined in *Use Your Head* plus physical training. In his own words: "I was getting nearer the exams. I summarized my last two years of school notes neatly into mind maps. I then colored them, highlighted them, and produced large master Mind Maps for each course, and in some instances for each major section of a course. In this way I could see where the more detailed elements fitted together, and in addition get a good overview, this enabling me to be able to "just flick through" giant sections of the course

"I kept reviewing these Mind Maps once a week, and as it got nearer to the exams, even more often. Next I made new Mind Maps, not looking at my books or other notes, simply drawing from my mind what knowledge and understanding of the subjects I had. Then I compared these Mind Maps with my master Mind Maps, checking the differences.

"I also made sure that I had read the key books, sorted these down to a few, read them in depth, and Mind Mapped them so that my understanding and memory were maximized. In addition I studied good essay form and style, and used my own Mind Maps as a basis for practicing essay and examination writing.

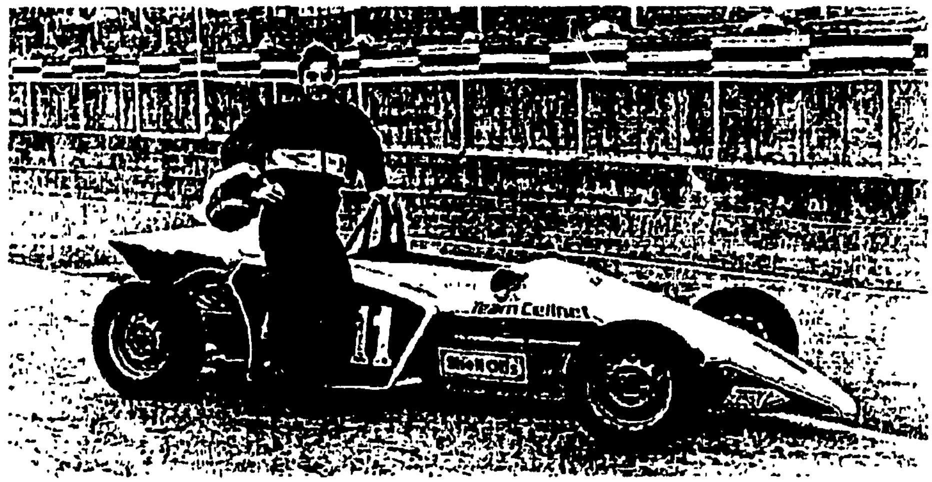
"I accompanied this by getting fitter, by running two or three miles, two to three times per week, getting lots of fresh air, and working out in a gym. I became better physically, which I found helped my concentration enormously."

Finally, Edward took his examinations. His results were:
Geography: A- Top Student,
English: Distinction - Top Student,
Medieval History: A - Top Student,
Business Studies: A and 2 Distinctions - Top Student.

These were the best marks the school had ever had. Within a day of the publication of the results, Cambridge confirmed his acceptance at the University, as well as accepting his request for a "year off" to see the world.

Before going to Cambridge, Edward decided that, in addition to academic success throughout his time at university, he would set himself the goals of creating a new student society, playing lots of sports, making many new friends, and basically having "a tremendous time."

In sports he was immediately successful, playing on the college soccer, tennis and squash teams. And in the area of student societies, he might even be termed an over-achiever. In addition to founding the Young Entrepreneurs' Society, the largest of its kind in Europe, he was asked to preside over the Very Nice Society, a



charitable society of 3,600 members. Under his guidance its membership grew to 4,500 — the largest society in the history of the university. In view of his work for these two societies, the other society presidents asked Edward to form and preside over a society for presidents. This he did and became the first president of the Presidents' Club.

Academically, he first studied the habits of the "average student" at the university. He found that most students spent about 12-13 hours a week reading for each subject, linearly noting all the information they could, reading all possible books, after which they'd spend three to four hours writing up the given assignment. Some students would actually rewrite their assignments, occasionally spending an entire week on one essay.

In view of his own experience, Edward decided to allocate a total of two to three hours a day, five days a week to study. As he described: "Those three hours would include going to the lecture and summarizing all the relevant information in Mind Map form. As soon as any assignments (essays) were given I'd go away and do a Mind Map on what I knew about the subject or what I thought was relevant. And then I'd leave it for a couple of days, think about it, turn it over in my mind. Then I'd speed-read the relevant books, Mind Mapping the relevant information. I'd then take a break or do some exercise, and come back and do a Mind Map on the assignment itself. Then after another break, I'd sit down and write the essay, always within 45 minutes. With this technique I regularly achieved good results."

Before the final Cambridge examinations, Edward worked to a similar schedule, preparing for six final examinations. The results? In one he was given a pass, normally considered "fair", but here "excellent" because 50 per cent of those taking the examination failed it, and no first places were given. In the second, third and fourth exams he achieved the highest marks in the class. And in the two other final exams, he achieved the highest marks ever received in the university for those subjects.

Immediately after graduation Edward was offered many jobs, but chose one as a strategic thinker for a multi-national company, a job described by the university as "one of the best ever" for a Cambridge undergraduate.

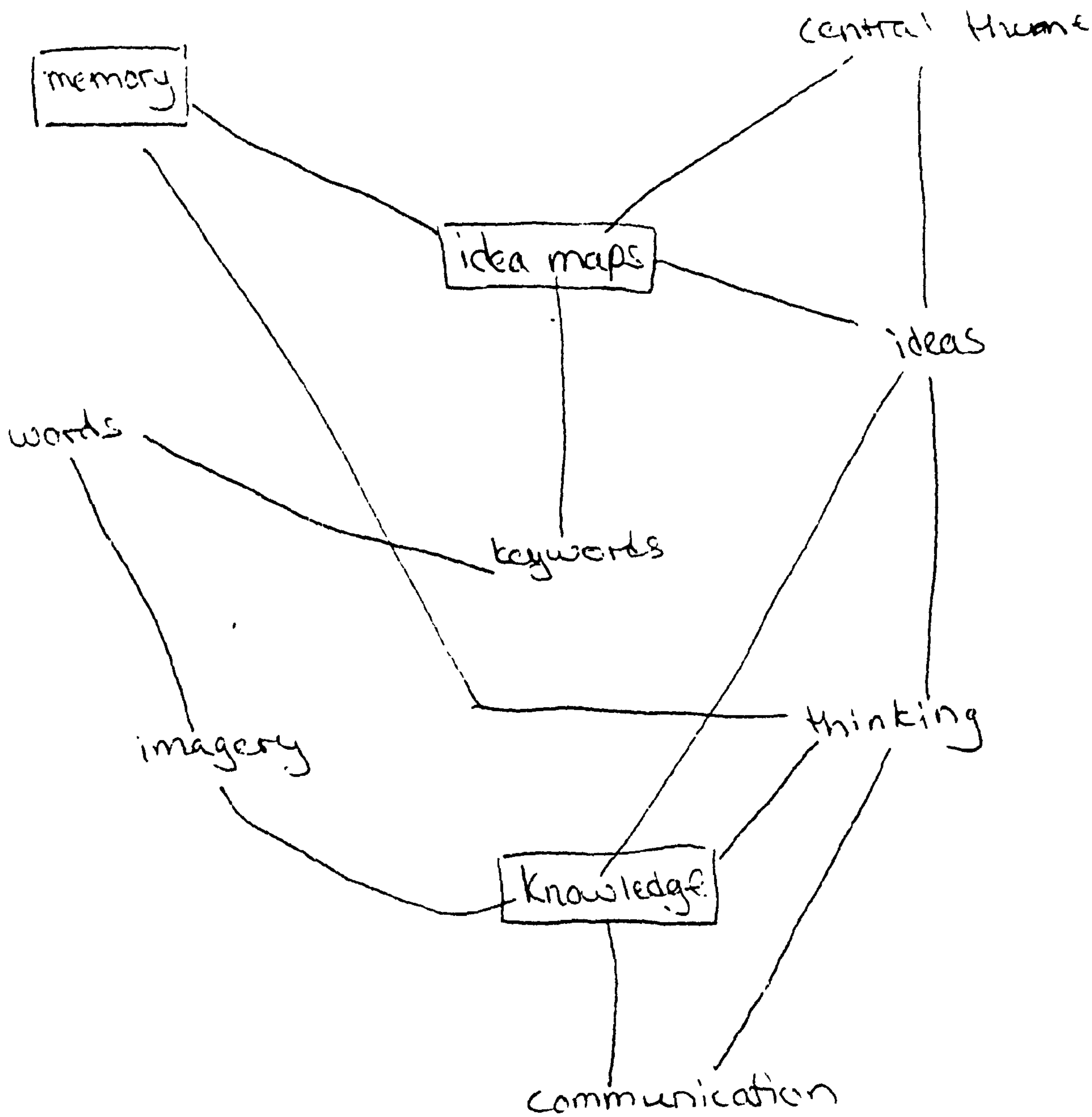
As Edward summarized: "I got a lot out of Cambridge — a lot of friends, a lot of experience. I played a lot of sports, was successful academically, and had three years of absolutely fantastic enjoyment. One of the main differences between myself and the others was simply that I had a strategy for studying and thinking — how to use my head. I was a C and B student before I knew how to get an A. I did it. Anyone can."

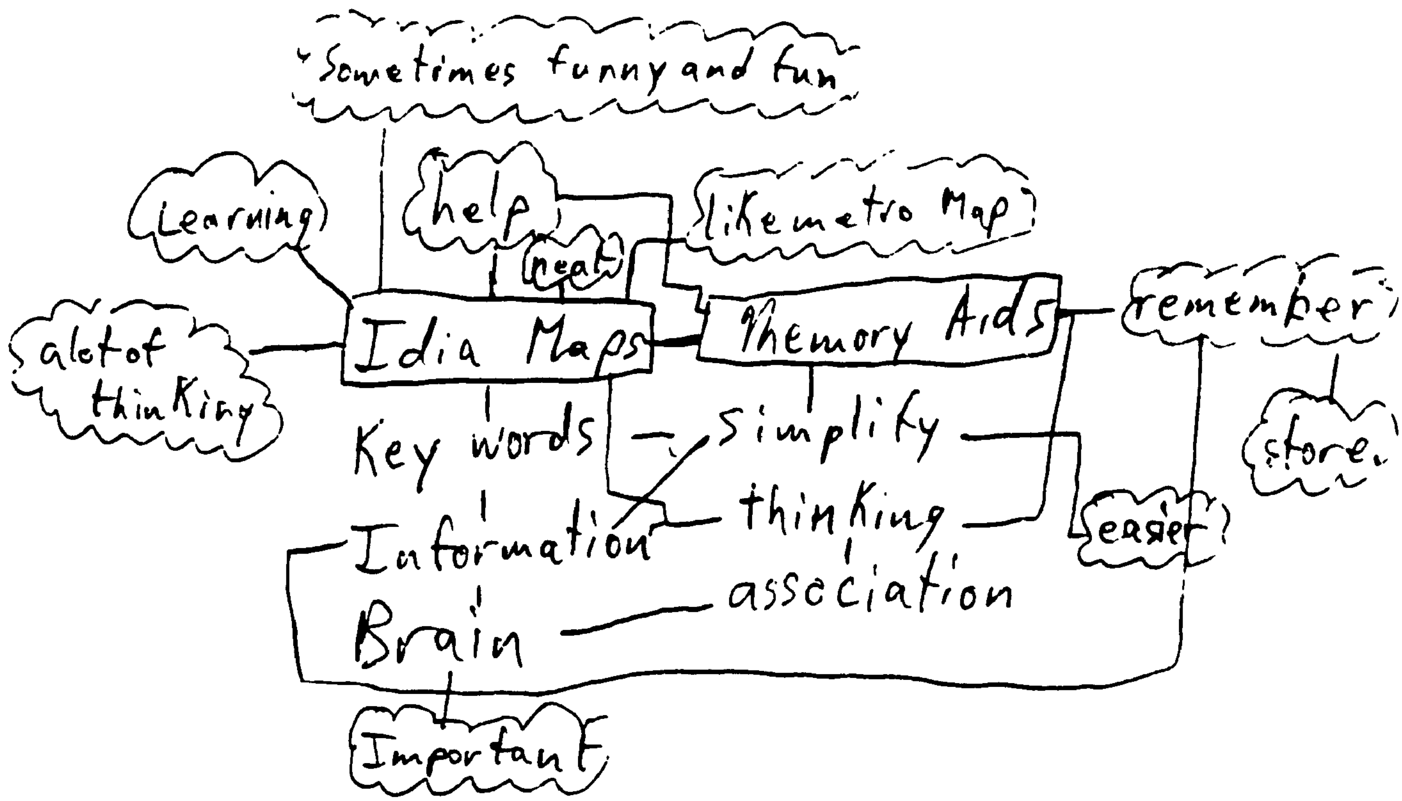
Adapted from Synapsia Magazine

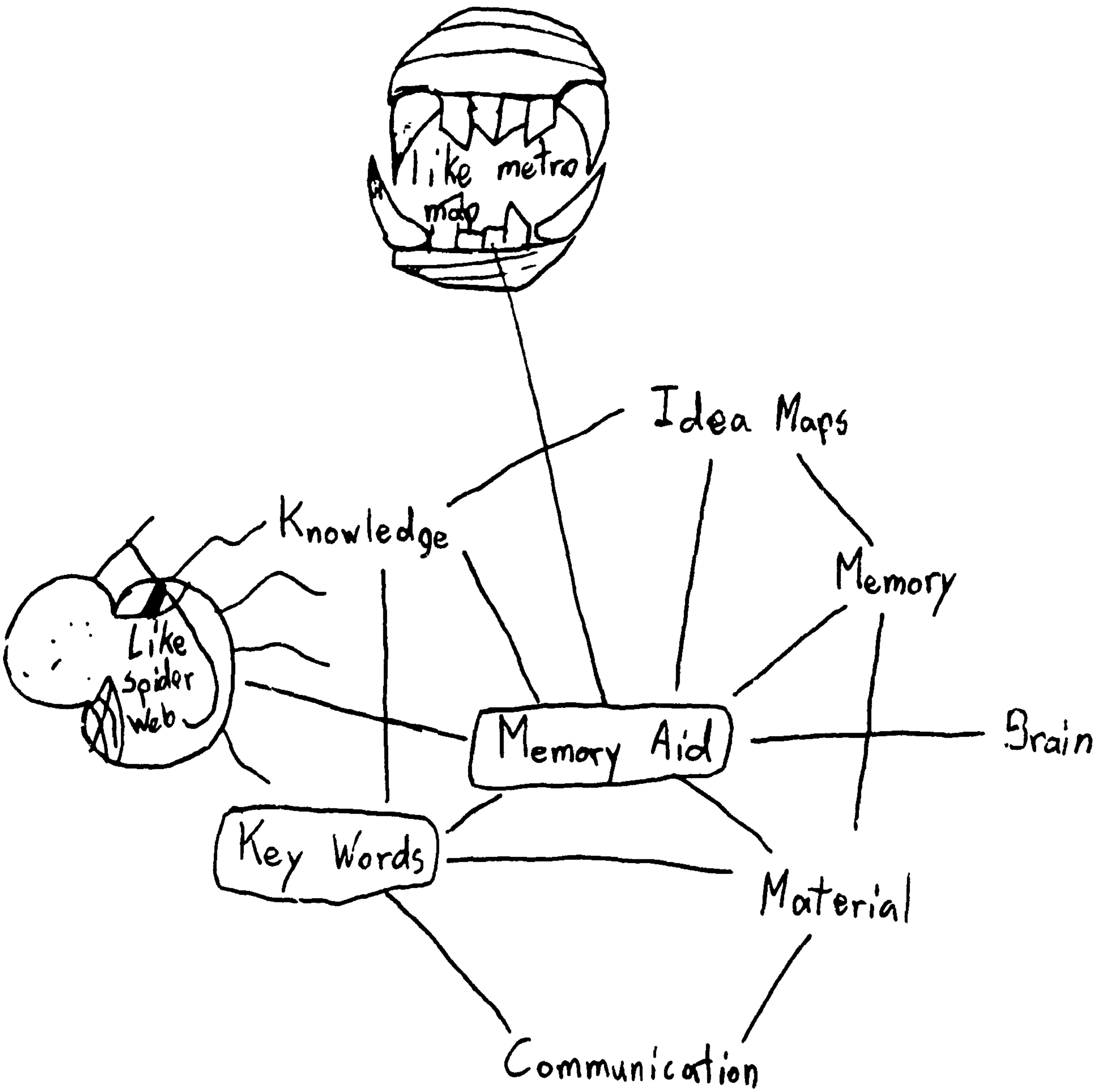
Appendix G

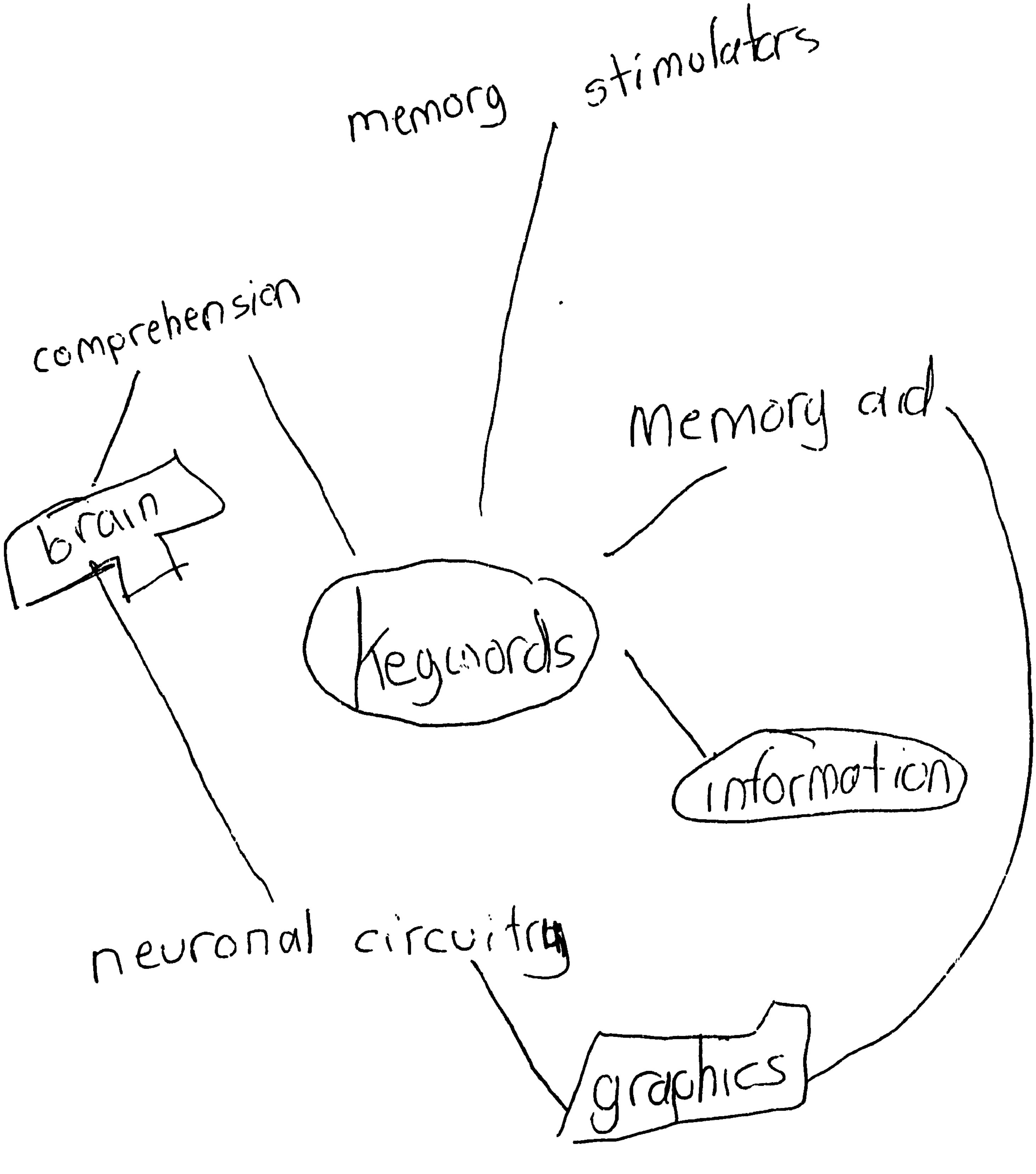
Examples of Maps Collected from Mapping Exercise in Phase 2

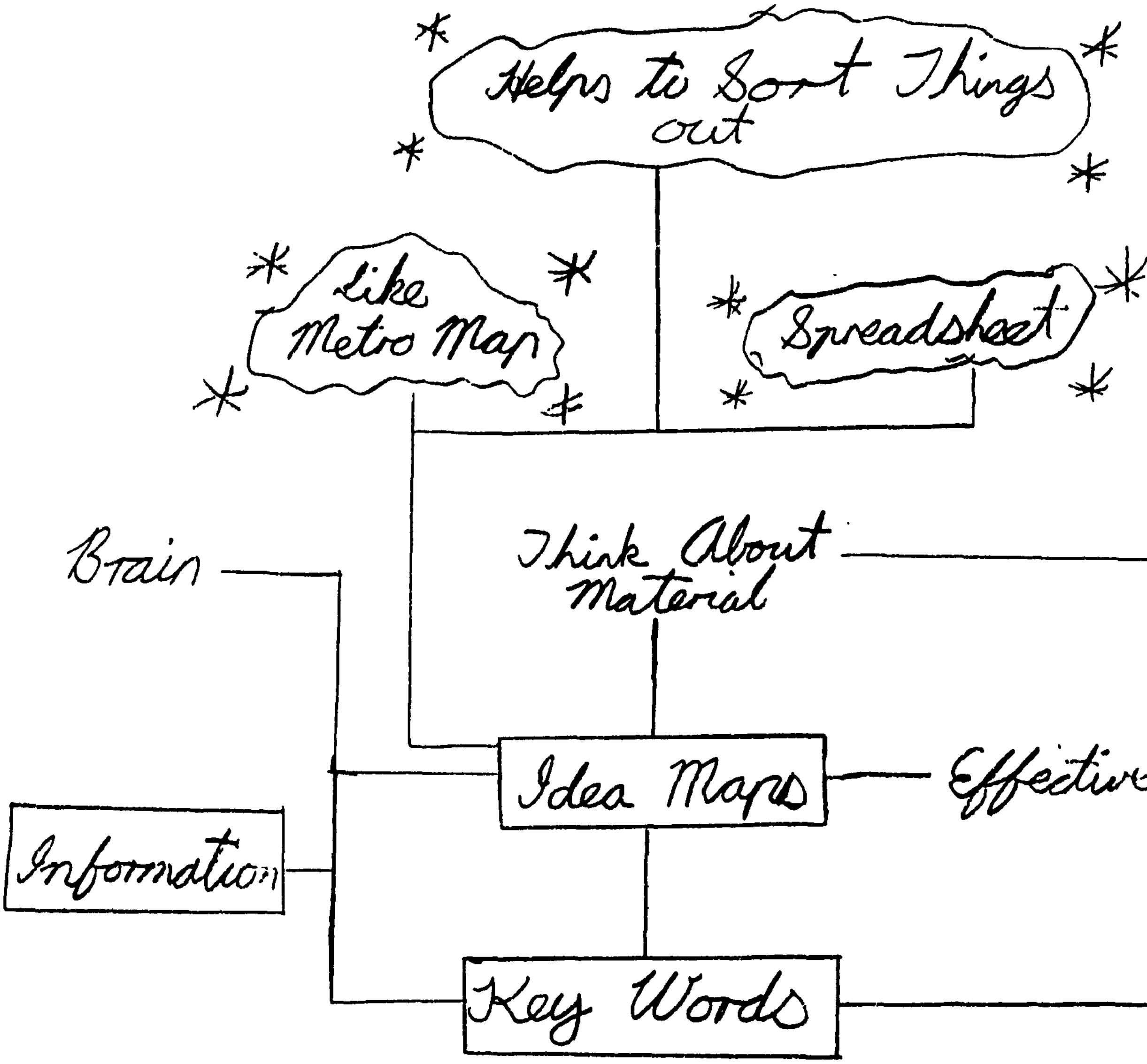
(Instructional Treatment-Part 2)

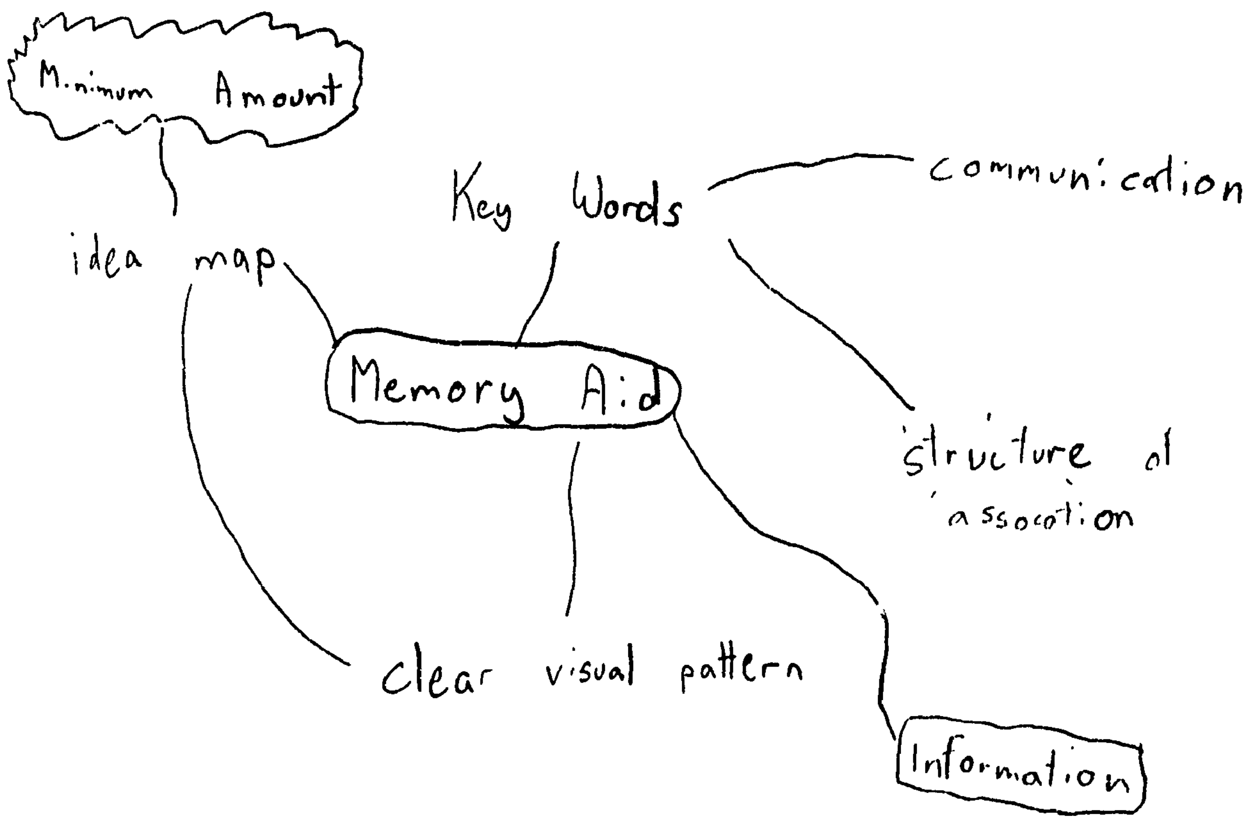

central theme
memory
idea maps
ideas
words
keywords
thinking
imagery
knowledge
communication


Sometimes funny and fun
Learning
help
neat
like metro Map
a lot of thinking
Idia Maps
Memory Aids
remember
store.
Key words
simplify
thinking
easier
Information
association
Brain
Important

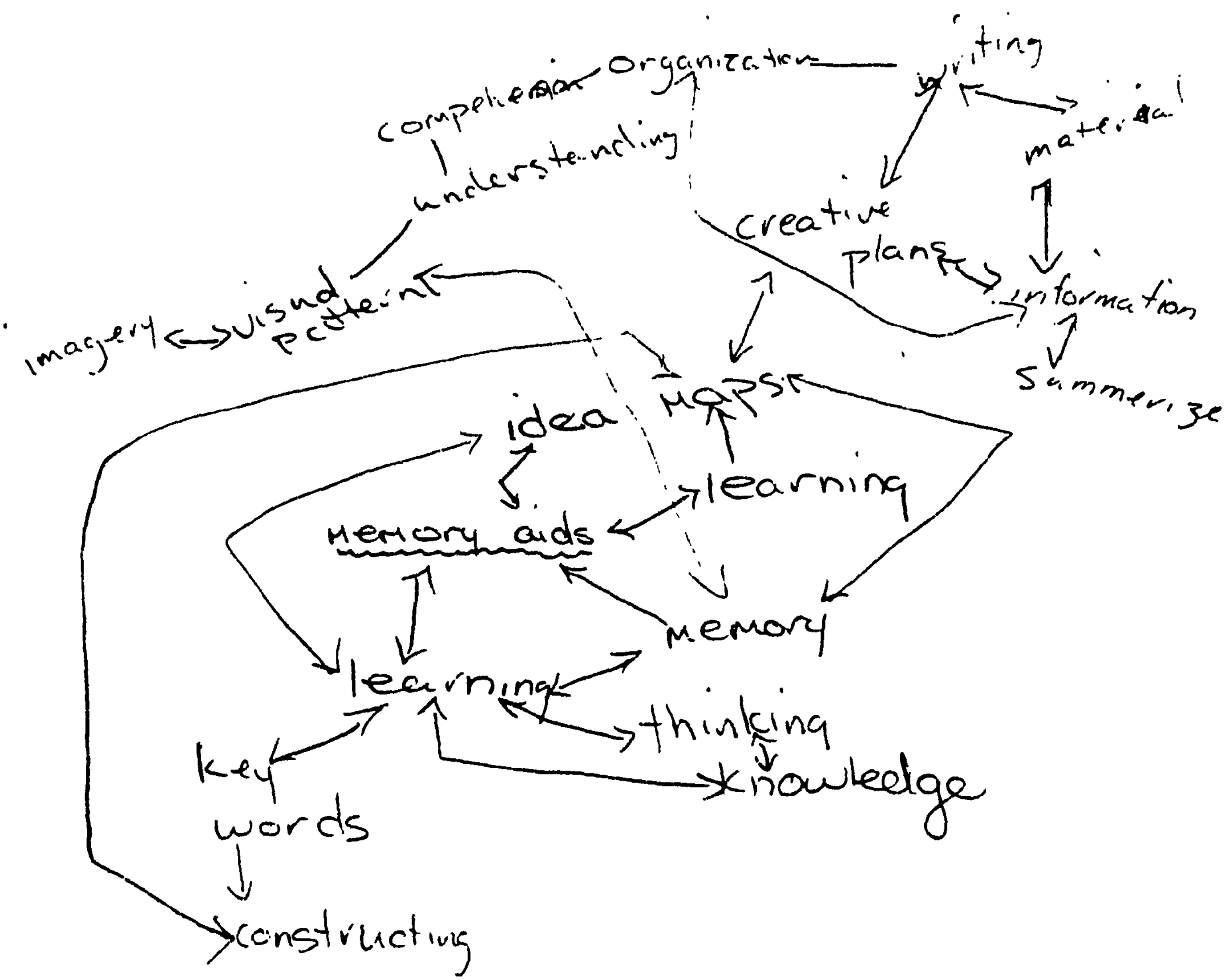

like metro map
Idea Maps
Knowledge
Memory
Like spider web
Memory Aid
Brain
Key Words
Material
Communication

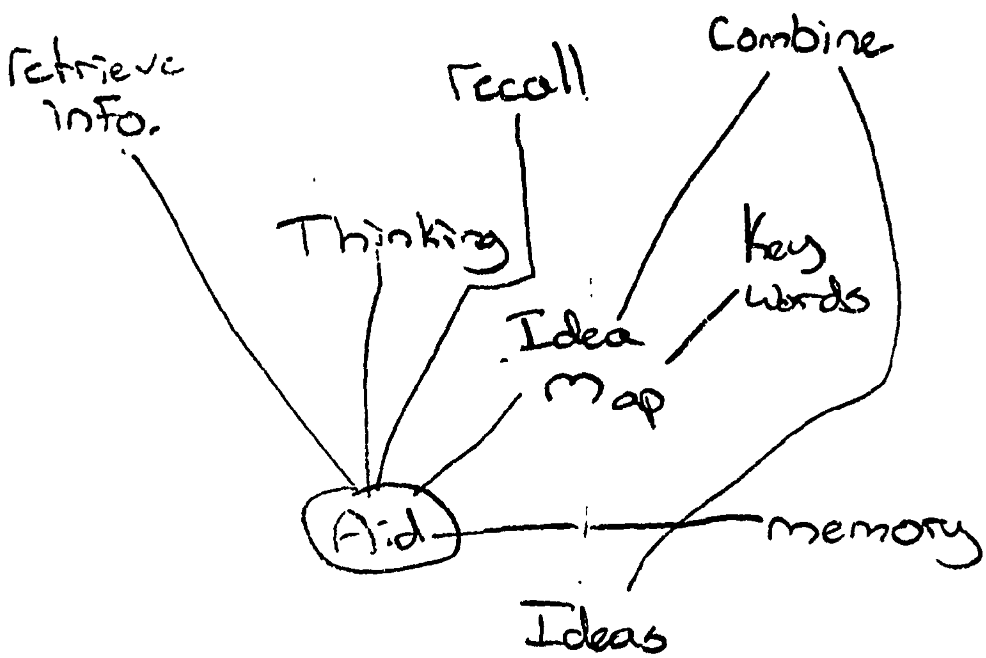

memorg stimulators
comprehension
brain
Memory aid
Keywords
information
neuronal circuitry
graphics


Helps to Sort Things out
Like Metro Map
Spreadsheet
Brain
Think About Material
Idea Maps
Effective
Information
Key Words



Minimum Amount
Key Words
communication
idea map
Memory Aid
structure of association
clear visual pattern
Information


comprehension
organization
writing
understanding
material
creative
plans
information
imagery
visual
pattern
summerize
maps
idea
learning
memory aids
memory
learning
thinking
knowledge
key
words
constructing


retrieve info.
recall
Combine
Thinking
Key words
Idea Map
Aid
memory
Ideas