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# **Metacognition: a Valuable Aid to Understanding for Medical Students in Problem-Based Learning**

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University of Glasgow

A thesis submitted in part fulfilment of the requirements  
for the degree of Doctor of Philosophy

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thesis.

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the spine.

Some images distorted

*to Tomorrow*



## **Abstract**

Since the beginning of time man has struggled with the duality of mind and body. Through the past few millennia philosophers, scholars and educators have found little to bridge this chasm; they succeeded in reducing their discord only by changing the question, not finding the answer. The delineation between these views of man has continued under various disguises. The attempt, in the 1950's, to unite the two camps under a single flag, cognitive science, has not been wholly successful. Scientists who claim this designation can still be divided, by virtue of their underlying beliefs, into one of the two groups from which they evolved. The unfortunate consequence of this division is not that exists, but the reluctance of its practitioners to utilise lessons learned by one camp in the practical application of their own work.

Almost every aspect of life involves learning and problem solving. It is an interesting contradiction that we have continually tried to separate academic learning from this natural function. One attempt to utilise this natural function in the academic arena is Problem-Based Learning (PBL). PBL uses real life problems as the impetus for learning. This alternative to traditional education has gained acceptance across a number of disciplines.

Research on concept formation flourished in the middle of this century. It was argued that we live in a world of concepts, not objects. A current trend in education that makes use of concept formation is Mind Mapping (concept mapping). This process concentrates on the arrangement of concepts. Its effectiveness relies on cognitive prompting by a visual representation and enhancing the retrieval of information via composite storing. We store chunks of information, concepts, with links attached.

Learning research has traditionally dealt with four agents: the learner, the teacher, the setting and the curriculum. My particular interest is the learner, the learner, and the learner. Each learner is unique. Both PBL and Mind Mapping embrace the idiosyncratic nature of the learning process and allow the individual student to make use of their own knowledge base, their own disposition towards learning and their own problem solving abilities to achieve the learning objectives we put before them.

As the number of problem based programs continues to grow so does the interpretation of the PBL format. At this time when confronted with a program designated PBL all we can say with confidence is that the primary transmission of information to the students is not the traditional lecture. This expansion is largely due to advances in cognitive psychology and learning theory which indicate that understanding is enhanced by allowing the individual student to select their own path to the learning objectives. The effectiveness of PBL is diminished if the students apply the same learning strategies that got them into the program. By necessity these are very good students, they have excelled in the traditional format that rewarded rote memorisation and factual recall. These skills are not wasted in PBL but alone they are insufficient to reach the theoretical goal of these programs.

In general, students in small groups are presented with a 'problem' (patient scenario) which serves as a stimulus for learning, i.e. what do you need to know to understand this problem. Many programs have no desire for the students to find a specific answer to the problem; 'that will only narrow the focus of their investigation, let the individual student decide how much they need to learn, if they think that a diagnosis is all that is necessary it defeats the purpose of PBL'. The students are armed with a vague destination but no real idea how to reach it.

This study involved the first year medical students at the University of Glasgow and was designed to instil the students with metacognition. The students were briefly introduced to the concepts of context specificity, rote memorisation, and the variation in learning styles. They were then given instruction in concept mapping stressing the metacognitive comfort of chunking and linking information. Emphasis was placed on thoughtful reflection and the integration of various disciplines. The students were told that the quality and effectiveness of their concept maps could not be assessed by anyone else.

Following their normal process the students, in small groups, read the patient scenario, listed the main issues on the board and discussed each in turn. When the discussion was completed six to eight questions were generated based on gaps in knowledge highlighted during the discussion. The students individually sought answers to the questions posed. Before returning to their group for a final discussion of the questions the test subjects were asked to; put away all notes and texts, reread

the scenario, using the 3-part NCR form provided construct a concept map indicating how you understand the problem, tear off bottom page of the form. The students were then instructed to take out notes and texts and make any corrections or additions desired, then tear off the bottom page of their form. The two concept maps were turned in at the beginning of the next PBL session. The students retained the top sheet of the 3-part form for their notes. Data was collected from 9 PBL groups for 10 scenarios, 546 2-part maps in all.

The collected concept maps were analysed for general layout and quantity of data but not for accuracy. This analysis yielded some insight into concept formation and a quite surprising consistency of data bits for an individual over a variety of scenarios. A pooled t-test was employed to compare the final exam scores of the test group to the scores of the remaining first year medical students. This comparison indicated significantly higher scores for the students in the test group. Student attitude toward the use of concept maps as a study aid was assessed via an end of the year questionnaire and 12 interviews.

Student awareness of learning theory and a reflective study style enhances understanding.

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## Chapter One

### *History, past and future*

*“And in much of your talking, thinking is half murdered.  
For thought is a bird of space, that in a cage of words may indeed  
unfold its wings but cannot fly.” (Kahlil Gibran, 1926)*

One is not alone in feeling as Gibran does when one tries to describe the notions, ideas, theories and certain truths that seem so obvious to oneself. This is in fact a great paradox that faces educators. When I reach the final page of this work it will end as it began. The idea that thought is internal, personal and requires space will be woven through the fabric of every page.

Education began when the first mother tried to convey to her offspring, dwelling in her shade, what one eats and what eats one. The fact that this educating is not exclusively human has provided many insights to human educators, but also created a number of blind alleys, some of which were not identified until so many twists and turns had been taken that returning from them has proved a long and arduous task. No species relies less on instinct and more on the ability to learn and to think, in the broadest sense. To fail to develop one's potential in this regard is to preclude the full expression of one's humanity, in the Darwinian sense.

From the beginning of time man has struggled with the nature of the mind. The enigma was not the invisible recording of the world around us, but the mental manipulation of that world. The ability to twist, bend and extend reality to our own highly personal view of the world, has attracted and confounded the most gifted scientists and philosophers through the ages. The question was and is 'how can the whole be more than the sum of its parts'?

## 1.1 From the Ancient Greeks to the Twentieth Century

Long before Descartes, the ancient Greeks struggled with the dualistic nature of man. It was not the complete separation of mind and body that was to follow. It was the apparent competition of opposing forces, attraction and repulsion, 'love and hate' (Empedocles, 455 BC).

The Sophists, perhaps the first formal educators, struggled with the nature of man and knowledge. They denied the possibility of passing beyond ideas. To them the interpretations that had come before were all false, all that was left for knowledge was the body of ideas itself. Man, the possessor of ideas, was the measure of all things.

Socrates opposed the Sophists. Using his celebrated questioning method, he attempted to have them admit a general form of knowledge, a commonly agreed definition of a thing, which was more reliable and true than mere individual opinion. Truth then comes to be found in collective or common acceptance; truth and knowledge are social. It is man in the sense of humanity not man the individual, in which the true subjective point of view resides. None of Socrates' actual writings exist, we know about him through the writings of Plato. Therefore, Plato reports Socrates said, 'the only thing he knew, being in this wiser than other men, was that he knew nothing. This is however, to know something of meaning, limitations, and value of knowledge itself'.

Plato offered his 'theory of ideas'; concepts or ideas are not merely subjective states of mind but absolute realities existing in themselves. Every actual thing in nature has its absolute prototype in 'idea'. In the human person, reason or the idea is involved in matter or the body, through the presence of the soul. The soul as common principle partakes of the nature of both.

Aristotle (384-322 B.C.) was perhaps the greatest scientist and thinker of all time. His theory of knowledge was in three stages extending from sense perception, to imagination, with reason at the top.

For Pythagoras, nature obeys the law of 'number'. Every change may be supposed to follow a numerical order. The soul is the numerical harmony of the body, as the world soul from which it arises is the harmony of the cosmos. Life is governed by number in four stages; it is latent in seeds, it appears in plants, it becomes the sensitive soul in animals (in the heart), the rational soul in man (in the head). The soul has three parts; reason, intelligence and desire. Reason is found only in man, animals have the other two.

For Descartes (Chisholm, 1982), mind differs from body by its consciousness of its own thinking process. In this it finds the immediate evidence of its own existence, 'cogito ergo sum', as a peculiar mode of reality. He distinguishes mind and body as two substances separate and incompatible. The essence of the body is extension and the essence of the mind is thought. These two substances are known in different ways; they form the subject matter of different scientific interests and thus are investigated by different methods.

The dominant problem of the thinkers immediately following Descartes was the psycho-physical one; how could the two heterogeneous substances, mind and body, sustain any relation at all to each other.

Spinoza (Hampshire, 1951), a pivotal figure in mathematics and philosophy, made perhaps the final statement on the Cartesian dualism, admitting the truth of the distinction between mind and matter, and that of the impossibility of any interaction between them. There is, said Spinoza, one other truth equally indisputable; the changes, relations, and events taking place in them occur in strict correlation, 'the order and connection of ideas is the same as the order and connection of things'. Spinoza attributed this link to their equal dependence on the 'one infinite substance', God.

This change in philosophy in one sense only replaced dualism with the double aspect theory. It did make it possible to pursue the sciences of psychology and physiology without embarrassment from the problem of interaction.



## 1.2 Gestalt Theorists

Gestalt psychologists were concerned with perception, the relationship between the parts and the whole. The whole is perceived first and only then can it be broken into its components. Max Wertheimer (1880-1943) a Gestaltist explained, 'what is given me by the whole does not arise as a secondary process from the sum of the pieces as such. Instead, what takes place in every single part already depends upon what the whole is. One hears the melody first and only then may perceptually divide it up into notes'. Similarly, in vision one sees the form of the circle first, it is given immediately. Only after this primary apprehension might one notice that it is made up of lines or dots.

## 1.3 Behaviourists

Until the mid 1950's, behaviourism was the prevailing view in psychology. B. F. Skinner (Skinner, 1974) and other behaviourists believed that the science of a person's mental makeup had to be based completely on observed behaviour. Explanations of student learning were bound by observable responses to observable stimuli. The unobservable and therefore mysterious mental processes were scientifically inadmissible.

The behaviourist would expose the subject to the appropriate environmental stimuli and then reward the desired response. Education was based on the presentation of small controlled bits of stimuli, students were asked for a response and reinforcement was dispensed. This process was continued until the stimulus-response (pair) was conditioned (automatic).

This behaviourist theory and process was simplicity itself, but life is not simple. Even when observing much of the research, done on animals, one often wondered who was teaching whom.

Many years ago in Psychology class we had been covering behaviourism and had spent a few days watching films of field research. A few of us 'with more energy and curiosity than good sense' conspired to do our own experiment. We gave a quick covert lesson in behaviourism to our classmates in History. Our goal was to control the behaviour of the History Professor.

The Professor's normal habit was to pace from one side of the hall to the other while lecturing and to use all of the two blackboards that stretched across the front. Our first step was to divide the right-hand board in half. When the Professor crossed the mid-point of the right-hand board either pacing or writing, the class paid no attention and were either disruptive or sullen. The behaviour changed immediately when the Professor returned to the left. We continued this process slowly moving the line of reactivity to the left. Except for a couple of confused expressions, the Professor remained unaware of our experiment. By the end of the second class, just under three hours total time, we had reduced the width of the hall to one-fourth its actual size and the Professor was using only the left side of the left-hand blackboard. The Professor, likewise a behaviourist, could conceive of no other learning taking place in his classroom other than that of history. But, who was becoming conditioned? This bit of juvenile behaviour illustrates the shortcoming of the behaviourists approach, what you see is not always what you get.

It is considered a gross misunderstanding of the behaviourists position to say that they don't deny that mental states exist, they merely prefer to ignore them. Their response would be along the line; yes we ignore them the same way a pharmacist would ignore voodoo, witches and leeches. They are relics of the past and will not reappear. The dark mysteries of the mind will yield their secrets through observed direct repeatable behaviours. The behaviourist believes that thinking is the organised interplay of laryngeal and related muscular activity associated with language.

It is unfortunately true that the unlearned tendencies of dogs and chickens to respond have been studied more than those of men. Also, that the extreme complexity and intimate mixture with habits in the case of human instincts prevent studies of them from giving unambiguous and elegant results. If the beast is not simple, an adequate description of it cannot be.

## 1.4 Cognitive Psychology

It was becoming obvious by the late 1950's that there had to be a science of how we perceive, remember, learn, plan and reason. In short, how we process information. The era of cognitive science was about to begin.

Psychology shares with the other sciences (that concern changes in man's bodily or mental nature) the work of providing thinkers and workers in the field of education with knowledge of the material with which they work. Just as the science and the art of agriculture depend upon chemistry and botany, so the art of education depends upon physiology and psychology.

N. Chomsky (1956), a linguist, argued that a grammar built on behaviourist principles was not adequate to explain our use and understanding of language. The infinite number of acceptable English sentences could never be explained by a stimulus-response model. He offered a theory called 'transformational grammar'. This theory states that we store a small set of simple sentences, designated deep structures. A set of rules, surface structures, operate on the deep structures to generate the sentences that we use and understand.

Miller (1956) was troubled, or perhaps plagued, by 'the magical number seven, plus or minus two'. This thought provoking paper was primarily concerned with perception and what he called absolute judgements. A number of experiments were carried out on the senses, sight, sound, taste and touch. If the subject's absolute judgement was quite accurate, then nearly all of the information presented was recoverable as judged from their responses. As the amount of input was increased, in either quality or quantity, the subject began to make more and more errors, indicating the point at which their absolute judgement failed.

I found it unremarkable that more information was recoverable from visual input followed by audio which was slightly higher than touch and taste. Almost one third of our brain is involved in the sense of sight. These facts were not the focus of Miller's query, which centred on the near agreement of the failure threshold, as measured by predetermined bits of absolute judgement across all of the senses tested. Despite the obvious similarities he considered the range of absolute judgement and the range of immediate memory (working space) to be very different limitations. Miller states that absolute judgement is limited by the amount of information (bits) while working memory is limited by the number of items (chunks). He further states that these two very different limitations are coincidentally constants of about seven. The quintessential message of the paper was that chunks are independent of the number of bits of which they are composed.



Looking back at this work from the immense vantage-point of forty years of concentrated research, I am struck by the clarity of Miller's message despite some disagreement with the inferences made. What is perhaps a bit disheartening is that while most cognitive scientists say they are familiar with this work they think it supports the notion of working space being limited to seven plus or minus two chunks, and that is to miss the point badly.

As to the magic number seven, I agree with Miller

'the seven wonders of the world, the seven seas, the seven deadly sins, the seven daughters of Atlas in the Pleiades, the seven ages of man, the seven levels of hell, the seven primary colours, the seven notes of the musical scale, and the seven days of the week? What about the seven-point rating scale, the seven categories for absolute judgement, the seven objects in the span of attention, and the seven digits in the span of immediate memory? For the present I propose to withhold judgement. Perhaps there is something deep and profound behind all these sevens, something just calling out for us to discover it. But I suspect that it is only a pernicious, Pythagorean coincidence.'

## 1.5 Information Processing

Cognitive science and the computer age grew in parallel, feeding on and subsequently advancing one another. The information processing model of the time was immersed in this new technology. Stimuli were equated to the computer keyboard, which provided information. Information was visualised on the monitor, working space, where it was expanded and manipulated. When we were satisfied with the information it was saved on the hard drive, long term memory.

An insight from computer science was that information storage could be characterised in terms of a data structure and the processes that operate on it. Newell and Simon (1956) expanded this notion with their description of a computer program called the Logic Theorist (LT). Stating that a physical symbol system has the necessary and sufficient means for general intelligent action. Hypothesising that



humans, like computers, have built in resources; symbols, operators and memories for constructing and running programs.

In applying this idea, cognitive psychology adopted the traditional data structure used in computer science, lists, trees, etc. This choice of data structure was not always driven by properties of the human memory system even though the properties of human memory are in most respects radically different from those of traditional computer memories. But there is more to memory than trace retrieval. An informational processing model must specify the informational content of the inputs and outputs and the goal of the computation. In human memory tasks information can be equated with what is made available by the test environment and by the subject.

We, the part of us that is we, is truly a CPU (Central Processing Unit) wired to think. We can no more avoid thinking than we can avoid breathing. All of us compare, classify, order, estimate, extrapolate, interpolate, hypothesise, weigh evidence, draw conclusions, devise arguments, judge relevance, use analogies and otherwise engage in numerous activities generally considered thinking.

The brain is the ultimate information storage and processing mechanism. As a storage vessel, it is considered by most cognitive psychologists and learning theorists to be limitless. How can anything composed of matter have an infinite quality? Is storing and processing information thinking? How can the brain compete with the storage capacity of today's computers?

The answer to the first question is relative. If something is infinite it extends without bounds. If we lack the ability to set that boundary or even conceive the notion of where the boundary might be, it is infinite.

Processing stored information is not thinking. Thinking is 'the ghost in the machine'. It is our flexibility and adaptability in processing information that allows us to learn.

Twenty-five years ago I purchased a 'Tandy' computer that played chess. I was an avid player of average ability and looked forward to many stimulating games. For a few weeks I was delighted with my tireless opponent that rarely made a mistake. I considered myself lucky to win one game in five. The 'Tandy' offered eight levels of

play and I was slowly progressing through the ranks. Upon reaching level four or five a pattern began to emerge, early in the game. 'Tandy' would trade a knight for a bishop. Whether a knight or a bishop is of more value is still argued by experts, depending on style of play, the stage of the game, and the pieces on the board. In making the trade the computer ended with doubled pawns, a weakened position if exploited immediately. I lost few games at any level after making this realisation, even though in many areas of the game my skills were no better than the computer. Playing 'Tandy' was no longer of interest, there was no ghost in the machine. Thinking is the ability to take advantage of past success or failure.

'Tandy' lost because it could not correct its error; surely I am not trying to imply that I processed more information. I confess, the computer was explicitly examining far more moves and board positions than I was. However, I am reasonably certain that 'Tandy' was unaware that the shop closed in 15 minutes, the cupboard was bare and my partner returning from work in an hour had no real interest in chess. Do not dismiss this comment as trivial or an attempt to be facetious. Research in cognitive psychology and artificial intelligence regularly address the question of mental storage capacities. Removing information from secondary or periphery buffer zones on the edge of awareness is by no means trivial, in deed or implication.

As cognitive science has matured, it has diversified. It has grown beyond its initial ties to knowledge, whose definition is arguable but in the broadest sense is too narrow to contain all we attribute to cognition.

For reasons of intended clarity, researchers have used a reductionist approach, concentrating on single retrieval tasks of newly presented stimuli and then expanding their theory to free recall and multi-level retrieval. The inability to distinguish between current and previous learning has meant that researchers have artificially restricted experimental parameters. But, associations to unidimensional stimuli are far different from their associations in the context of a query.

Even ignoring the information being processed beyond the board, I wish to challenge 'Tandy' for the amount of information being processed. It was previously stated that the computer explicitly processed more data. When evaluating my next move there were certain areas of the board where I examined a few moves and positions



concluding that no good or harm could come from them. I argue that the thousands of moves and subsequent positions that the computer explicitly processed in these areas, I processed implicitly. This implicit processing may be distant echoes of positions I had seen before or the subconscious manipulation of positions that never were.

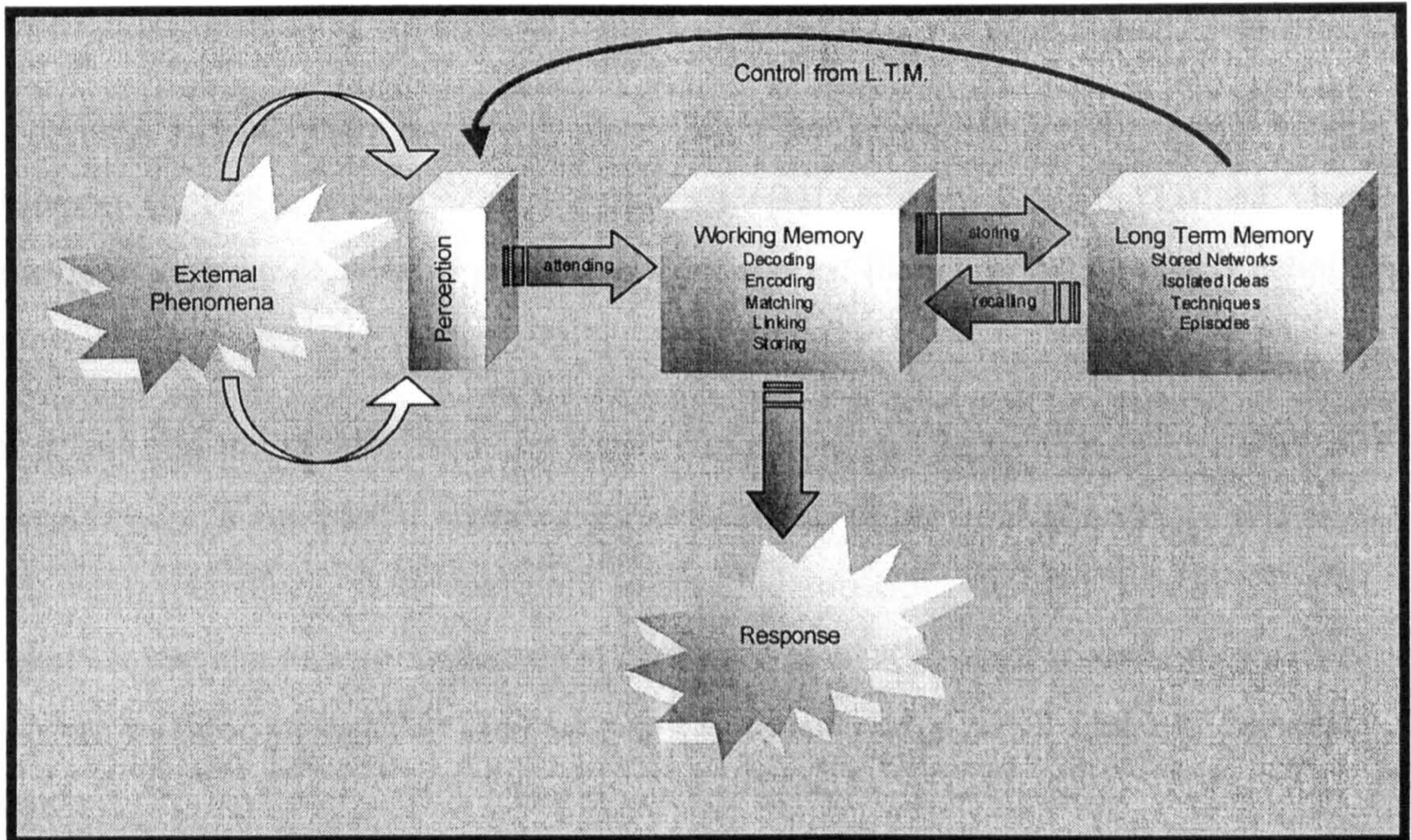


Figure 1.1 An information processing model.

More enlightened cognitivists have moved beyond attempting to understand the target by understanding the digital computer, rather they use the computer as a tool to understand the target by understanding the model. Even so, the model is far too restrictive managing only to mimic the apparently simple retrieval of a single response from a large database. The flexibility of human cognition, at even its most basic, confounds any attempt to be modelled on a hard-wired system. Computer models are built on data bits uniformly separated on tape or disc where neither the distance from nor familiarity with their neighbour is relevant. The theory is that they describe cognitive processes in much the same way as the physics formula for bodies in motion describes the position of the body at any particular moment. It then follows that if the time between positions is sufficiently reduced a smooth line indicates its exact path. This type of model only serves to deepen the confusion between



cognitive scientists of this ilk and psychologists confounded by the great diversity of their patients.

A current information processing model (Fig.1.1) was presented by Johnstone (1993, 1997). This model is elegant in its simplicity and from a holistic perspective is easily understood. However, when you place your hands on the individual pieces of the model it becomes quite slippery, eluding your grasp.

Incoming stimuli pass through a perception filter controlled by the Long Term Memory (L.T.M.). 'It must be driven by what we already know and understand. Our previous knowledge, biases, prejudices, preferences, likes and dislikes, and beliefs must all play a part', Johnstone (1997).

It is true that information from our sensory receptors, not being directly attended to, goes through some partial processing and matching to previous knowledge. To say that bias, prejudice,... is filtered prior to entering conscious thought is to imply that what we see and hear is mediated by what we know. A number of examples in the Gestalt tradition propel this idea, allowing us to see recognisable forms in apparent random dots and blobs. This takes advantage of the sensory receptor tendency for pattern matching. It is not an example of the difference between novice and expert which has also been called pattern matching. Research on patients with selective brain damage dispute this notion further. Some patients who appear normal in all other respects no longer recognise family and friends, but they see the same faces. In these patients and others, meaning is skewed but not perception. I would argue that the only perception filter is one created by how we label and subsequently file incoming stimuli. A filter, as Johnstone describes, might be better placed between Working Space and Long Term Memory. I concede that the arrow indicating control from L.T.M. may be argued in broader or narrower contexts as needed. Once again this model may have slipped through my fingers.

Information admitted through the perception filter passes into the working space. 'The working space is the conscious part of the mind, where information is held and manipulated before being rejected or passed on for storage. The working space has a limited capacity. It is a shared space where there is a trade-off between what has to be held in conscious memory and the processing activities required to handle it,

manipulate it, and get it ready for storage in L.T.M.', Johnstone (1997). Regarding the limitations of this working space Johnstone referred to an earlier work, Johnstone (1993), which described the capacity restricted to  $7 \pm 2$  chunks.

The tendency to break large amounts of information into chunks and to use this process to increase the limited capacity of the working space, is unquestionable. But this described working space, is significantly less than consciousness and significantly more than what can be directly attended to. Consciousness contains an inordinately large amount of peripheral information, a portion of which is related to and some having nothing to do with what is being attended to. As to the  $7 \pm 2$  chunks, it should not be necessary to say that  $7 \pm 2$  is a label meaning relatively small and finite. This is no doubt understood by Johnstone. But, whether these chunks are discrete or portions of larger structures and whether the capacity limit is related to volume of information or the time since attended, is questionable.

We now move to Long Term Memory (storage and recall). 'On a simple level one could compare storage and recall to a filing system in which new information is related to existing files and placed there.' Johnstone further describes the manner in which new information is added to our database, 'we are pattern seekers and build our own knowledge through idiosyncratic construction', Johnstone (1997). He then went on to distinguish between shallow learning, characterised by rote memorisation, and deep learning defined as interlinking and multidimensional.

In general, I am in agreement with this portion of the model and consider the message that knowledge is personally constructed in the mind of the learner to be of paramount importance. I might argue that pattern seeking is more likely a consequence of applying information held in the L.T.M. not the initial deposition of it.

Cognition must be explained by reference to complex internal structures. Our inability to fully comprehend these structures does not mean that any model of cognition must be built without them.

If the cortex is an associative memory, strongly connected cell assemblies will form when neurones in different cortical areas are frequently active at the same time. The cortical distributions of these assemblies must be a consequence of where, in the

cortex, correlated neuronal activity occurred during learning. This has implications for cortical topographies and activity dynamics of cell assemblies representing concepts.

Donald Hebb (1949) proposed a neuropsychological theory of cortical functioning that could be considered an alternative to both localisation and holistic approaches. A localisationist, Broca (1861), Wernicke (1874), would propose an area a few square centimetres of cortical surface as the locus for word comprehension. According to this view, the psychological process in question is restricted to an area and no other areas are assumed to contribute to the process. A holistic approach, Freud (1891), implies that the entire cortex exhibits equipotentiality with regard to all cognitive operations and that all cortical areas (or brain parts) contribute to complex processes. The Hebb model; stimulated by external input, either through sensory fibres or through cortico-cortical fibres, activity will spread to additional assembly members and finally the entire assembly will be active, creating a wave of excitation circulating and reverberating in the many loops of the assembly. The specific neuronal connections which these patterns are probably related to, have been labelled synfire chains, Abeles (1994). Sustained activity of the assembly and reverberation of activity therein may represent an elementary process underlying short-term or active memory, Fuster (1994).

It is my contention that not all areas of the brain are fully interconnected. But, all areas are connected in an associative network so that the results of some partial processing done in one area can be reported to another. This position is not altogether different from that of Hebb's and his followers. The primary difference is I believe that we can consciously explore and partially control these interconnected bubbles. It is not only possible to adjust their make up, but the amount of influence they exhibit over the whole. The difficulty with these chains is to maintain the links between while exploring the possibilities within.

A concept may be laid down in the cortex as an assembly including a visual, phonological, semantic,... and other. After such an assembly has formed, activation of any of the parts will be sufficient for activating the others. It is necessary to allow for hierarchical organisations of concept assemblies where one assembly may be a



subset of another one. The elements of concept representation are strongly connected through distributed populations of nerve cells.

It has been proven that function words (and, or, not, if) are located in far different brain areas than those of content words (nouns and verbs). The complex assemblies of content words are absent for function words. Function words provide the frame for a particular query, but their use does not strengthen their association with the content.

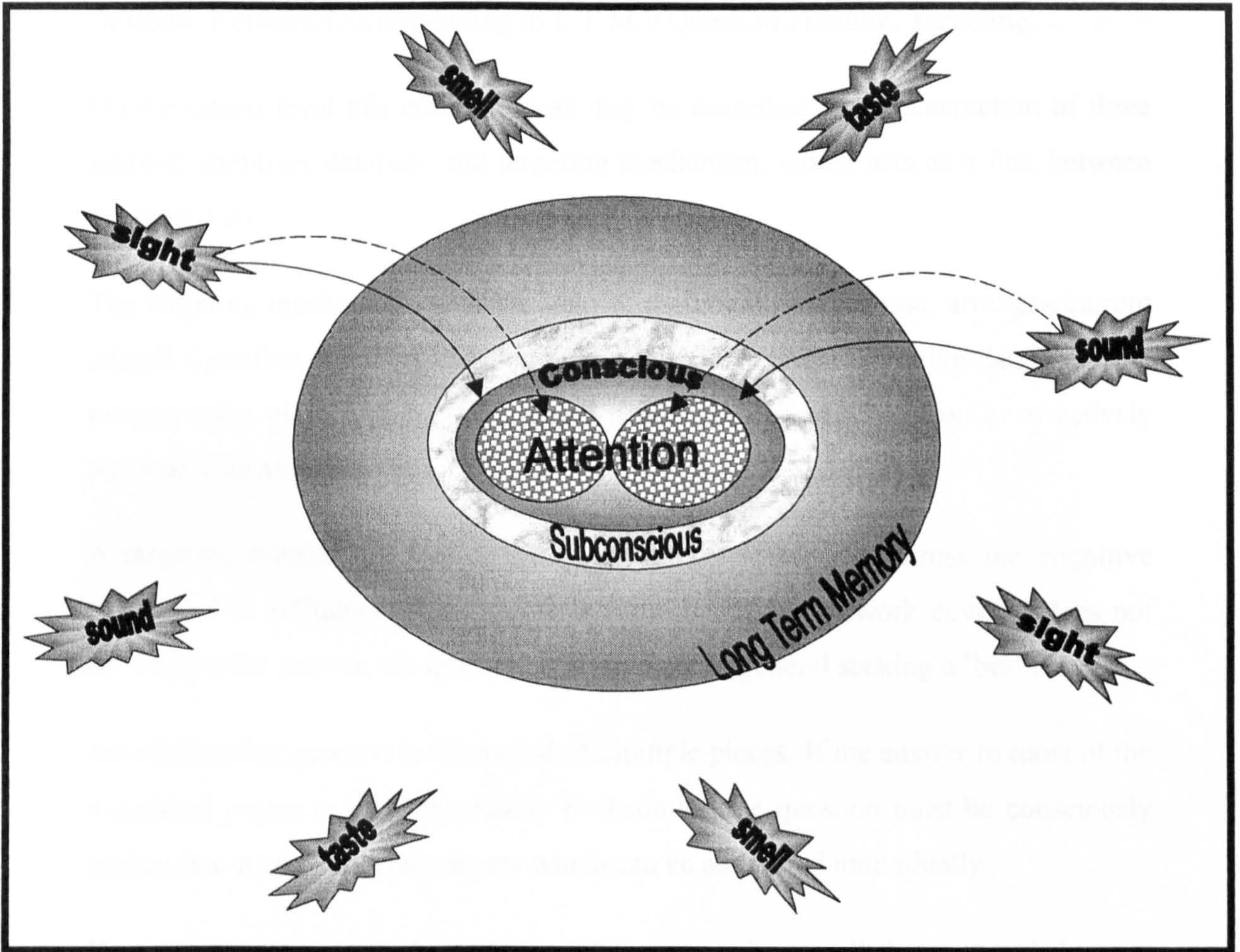
Genetic factors cannot be discounted; wiring of efferent and afferent cortical connections are genetically determined. Genetic factors are also important for the formation of cortico-cortico and cortico-subcortico fibre bundles which are a necessary condition for long distance association of coactivated neurones located in different areas.

These brain locations, such as superior temporal lobe, inferior parietal lobe, Sylvian fissures, amygdala (linked to emotion) and hemispheric lateralisation are of importance but will not be dwelled on here, for fear of irrecoverably fragmenting the image I am trying to present.

In information processing, memory searches and perceptual analysis are considered to be vastly different processes. I don't consider them so and postulate that a memory search provides another opportunity to analyse perception. I think that far more information is encoded than was used for placement or likely to be used in a simple reactivation. This surplus information was only surplus in the frame of the original recording and may provide insight(s) during analysis. The current information processing model indicates that incoming stimuli are filtered. As previously mentioned, I hypothesise that we associatively match incoming stimuli and it becomes labelled for the purpose of placement and the freeing of attention.

In forming any complete model, we should assess tendencies in areas we do not fully understand and marry these with evidence from those that we do. Much effort is devoted simply to establishing a coherent and reasonably precise framework for discussion. My model will match data qualitatively to a theory of cognitive processing. It is accepted that the distinctive complexities of cognition yield to scientific understanding only at some level of abstraction.





**Figure 1.2 Thinking, beyond the box.**

When not directly attending to incoming stimuli it is matched to existing data in the Long Term Memory (Cognitive Database) and sub or semiconsciously filed (solid arrow). This matching and filing is a result of partial processing by the sensory receptors within implicit parameters. Immediately acceptable stimuli in the lecture hall are far different from that of a busy city street. If the stimuli are sufficiently different preventing a match, they break in on attention (dashed arrow).

## 1.6 A Proposed Model of Information Processing

This theory is based on: observation of academia, from both sides of the bench; observation of business, both industry and agriculture; observation of both man and animal; and a reflective examination of philosophy, psychology and neurology as applied to educational and cognitive research; and finally pure introspection.

How do we answer a question?

In the Gestalt tradition, I will describe the whole (Fig.1.2) with only sporadic groping for support.



KEYWORDS: Attention (corresponding to Working Space); Database Structure, Database Network (corresponding to L.T.M.); Question Framing, Targeting.

On the macro level this entire process may be described as the interaction of three players; attention, database and targeting mechanism, which acts as a link between the other two.

The targeting mechanism, with the help of the cognitive database, arranges current stimuli (question framing) and this query then impacts the cognitive database. The process takes place within attention and is done to answer a question or to actively place new information.

A targeting mechanism frames the question and stretches it across the cognitive network. The influence of the frame is finite but if the network covered does not encompass the answer, the question is re-framed. In general seeking a 'best fit'.

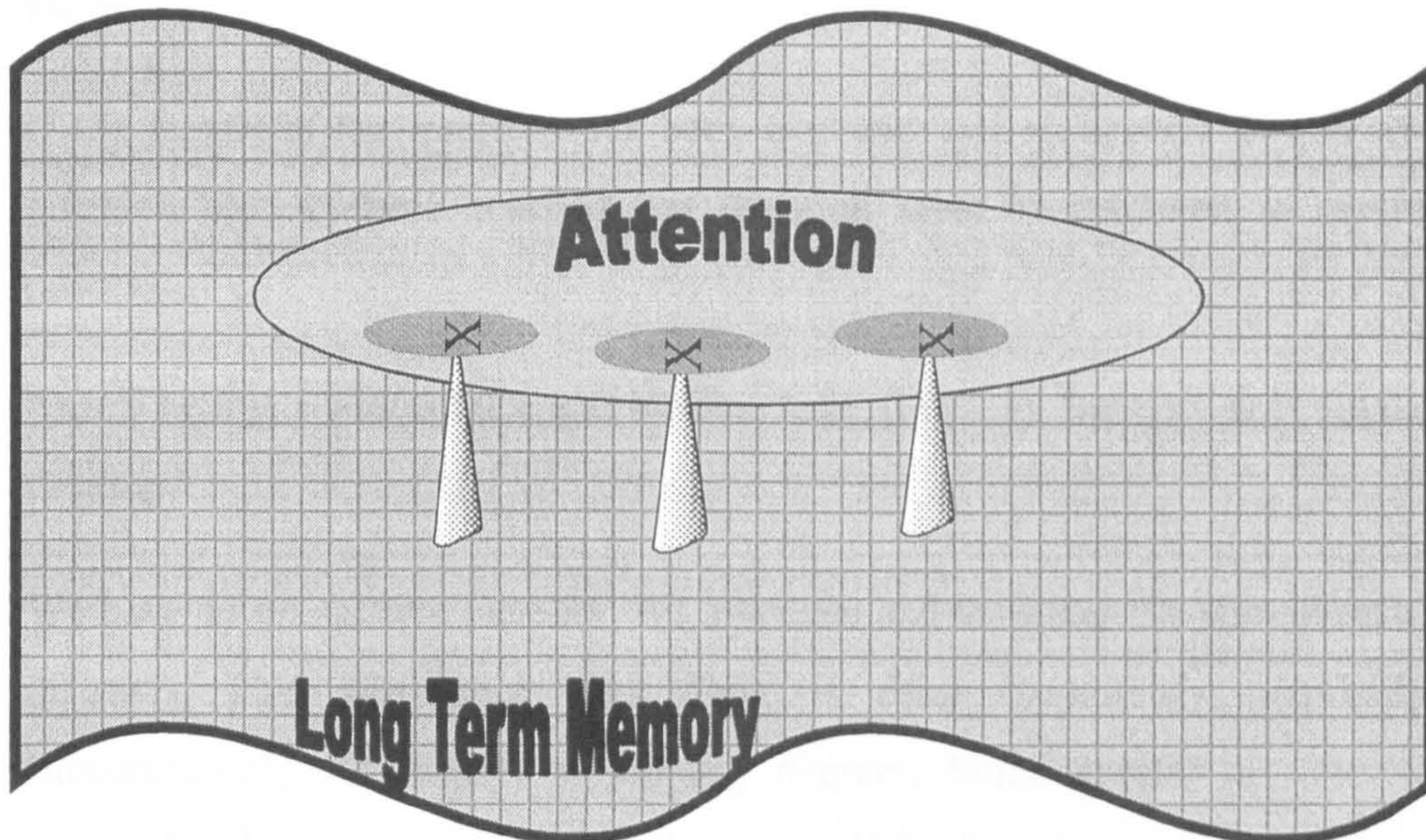
An open-ended question is composed of multiple pieces. If the answer to most of the individual pieces is not immediately forthcoming the question must be consciously broken into its smaller components which can be addressed individually.

How close contact is to the target, is a function of how well the answer is known. Simply, enhanced understanding enhances aim. The active arranging and shaping of the database enhances contact as well as the ease of exploration. Familiarity increases the likelihood that the network will condense therefore freeing attention for further use.

The data matches that I am talking about are on the micro level. An analogy of the model I am proposing on the macro level matches database to question resembling the 3D structure of a protein. This structure bends and contorts due to hydrogen bonding and other attractions bringing into play finite pieces of distant portions that form local environments, capable of attracting and coupling with in-coming data structures. This capability is on a continuum and performance is improved by a dense structure. The denser the more applicable; the more applicable the more pliable; the more pliable the more matchable; the more matchable the more condensing (requiring less attention). It may very well be, that actual condensing of the structure is only accomplished in reply to a direct match. Matches (insights) may be



accomplished sporadically through exploration of the structure, and correspondingly the shaping of the structure increases the likelihood of a match via question answering.



**Figure 1.3 Wilful information processing.**

As we search our cognitive network (Long Term Memory) to answer a question, portions of the network are brought into conscious attention. These are not finite pieces selected and severed from their associations. In the figure the three specific bits (X) of information brought into attention remain connected to their associations pulling these associations closer to the point of conscious attention.

Even when retrieving a single response,  $2+2=4$ , periphery information is attached, though in these cases held at some distance. We hold: historical associations; where and when we learned mathematics, who taught the class - general associations; four seasons, four stages of protein folding, four corners of a square and the dangerous semantic association 'fore' – immediate associations; four questions on the exam, four 10p coins in your pocket.

The cognitive network is then attracted to the framed query. Whether, the question is attracted to the answer or the answer is attracted to the question, or whether, they (question and answer) are chemical, electrical or topographical? ..perhaps, not relevant at this level of understanding, all three, I don't know. Your knowledge base aligns correct (exact) responses along the question. An exact match will be found only if the exact question has been asked before. Application of previous knowledge that fits very well, is applied and accepted (deemed correct). In all other cases, most cases, a partial match is made and then investigated. Your ability to investigate the



cognitive structure for a better match is limited by your available attention and is done in a stepwise fashion. As you proceed along the network to points of contention, you do so in the order that seems most sensible, constrained only by being tethered to the question via your attention span. As you explore a non-congruence, if a better alignment of knowledge can be found, the adjustment is made.

If the length of the question has been explored and an acceptable answer to the question has not been reached, the question must be reframed to continue the process.

That is how you access the cognitive data base, (Fig.1.3). But how does the data base develop?

We have an associative memory; we associate and therefore file stimuli (external or internal). This associating and filing is done consciously (explicitly) and subconsciously (implicitly) to varying degrees. Some stimuli are very quickly matched and accepted subconsciously leaving little if any trace.

All stimuli carry with them peripheral information that remains unexamined until you go looking for it. Examining and placing this peripheral information is not trivial and its examination enhances understanding, primarily by reinforcing and condensing the data that supports it. It is likely that it is not practical, or even possible, to explicitly explore and file incoming stimuli as it is initially received. How are stimuli filed?

Consider, the normal day to day stimuli you encounter when walking down the street. If you are walking along and your mind is otherwise occupied by where you are going, or what your going to do when you get there, or what's on the TV tonight, then all of the stimuli (visual, audio, tactile) are semiconsciously and subconsciously received and matched to previous experience and then relegated to a buffer. Not a chronological buffer, but an ordered one where novelty below the threshold of consciousness impacts placement. Unless the stimuli are sufficiently different so as to prevent a match, this process does not cross into consciousness.

Conscious attention to stimuli is done by arranging exploring and rearranging one's cognitive data base to fit posed questions either explicit or implicit. In this case the posed question is simply 'what is that?'. The depth of this exploration is regulated by the amount of conscious attention given to the task. The series of knowledge chunks that align themselves with the question are composed of multiple parts whether they are sensory, theoretical or a combination of them. Through careful reflection, the individual bits of these knowledge chunks can be explored and their placement adjusted. Learning is accomplished by applying information and this application can and should be learner directed. To be precise, I don't think knowledge can be mediated by anyone other than the learner. This process is not facilitated by traditional education but happens in spite of it. In the traditional educational arena, it happens as a by-product of an industrial process. The process is supplying the answers to questions we will pose later for assessment. If the students find meaning and understanding from the words it is secondary to successfully passing the course.

How does learning interact with the cognitive database?

The more the data is integrated the tighter and more condensed the structure. A condensed structure encourages a match to posed questions and requires less attention to access, both of which work in concert to improve student performance. When new information is added to the structure, it is attached to the appropriate association one level removed. As with all stimuli, it comes with unseen layers that remain hidden until explored. This hidden information can remain dormant for years.

Does the hidden information fade with age?

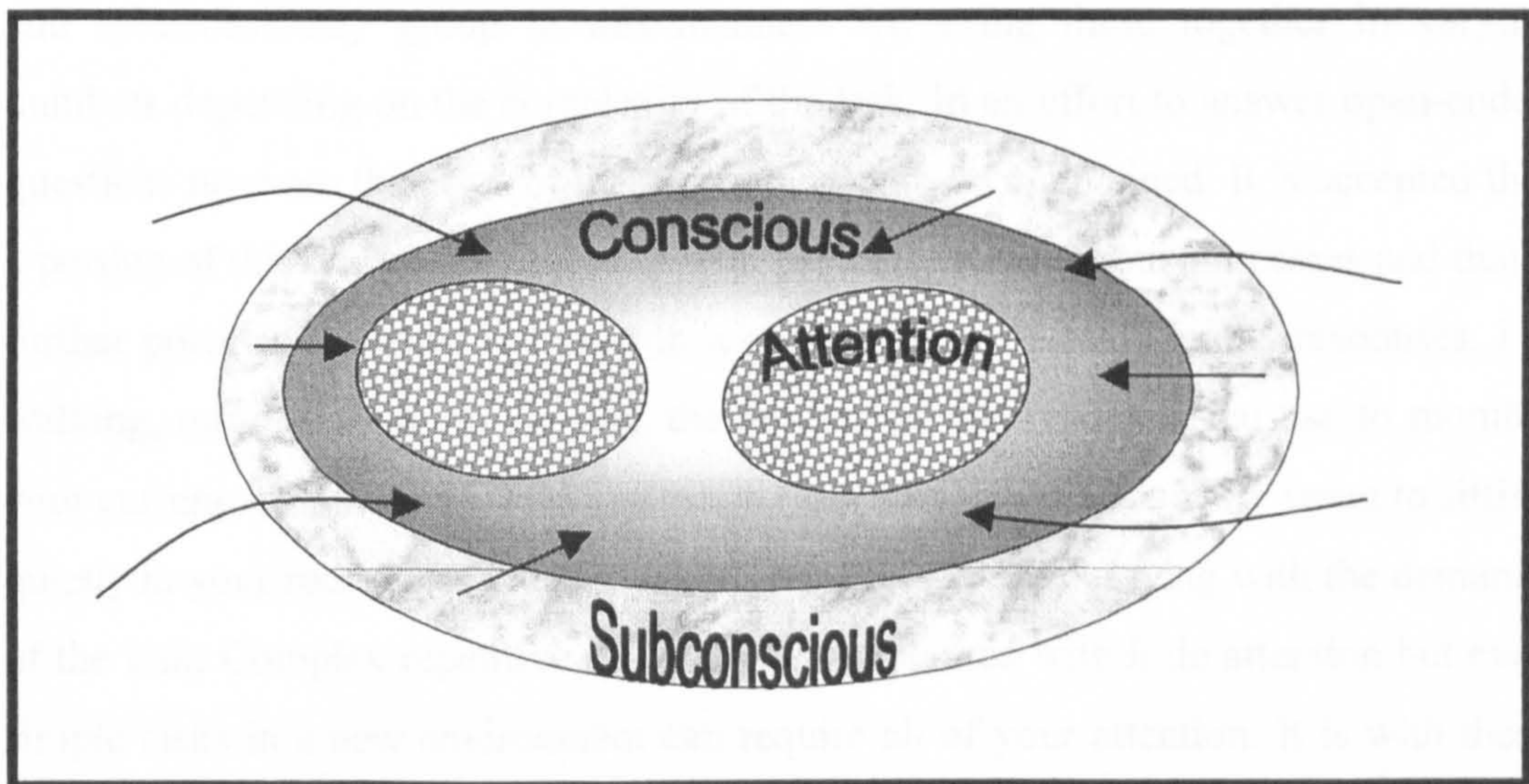
Maybe, perhaps, probably - it depends on which part of the cognitive structure the hidden information resides. This is a difficult point. It seems amiss to say that some areas of the mind are inferior to others. What is being considered are peripheral buffer zones, where some partial processing takes place and which may possess their own storage systems. If so, the storage capacities of these sensory buffers would logically vary with the proportion of the brain involved in the processing of the particular sensory stimuli. Genetics and early learning tendencies combine to form personal idiosyncrasies that are directly related to individual learning styles. It seems that both the audio and visual sensory receptors have a better filing system and



episodic stimuli can remain intact practically forever. With difficulty these receptors can be explored. When a sensory stimulus is recalled the applicable receptors are reactivated. The reactivated receptors contain not only the remembered (labelled) impression, but background information that can be explored. Stimuli created internally carry with them this same baggage with the sensory receptors once removed. It should be noted that the shape of the data condenses with use and understanding but, it does not take on the shape of a pile of dirt that is continuously run over, smoothing out the lumps. It is sculpted by the individual artist taking on the twists and turns of the one that created it. Knowledge is a personal possession that can never be given away.

The targeting mechanism interacts with the cognitive network within attention. What is attention?

Paying attention is an apt expression because attention is a valuable commodity that in times of need is doled out in miserly portions.



**Figure 1.4 Loss of Attention**

Stimuli not directly attended to, both internal and external, may break into conscious thought. In some cases this is a result of an immediate match not being found. At other times our focus on attended stimuli may relax, providing greater impetus for the ever-present tendency to wander through the cognitive network. Both cases result in a reduction of the precious resource, attention.

Attention is the only means we have to interact with the outside world, whether that's outside the body or just outside conscious attention, Fig.1.4. Attention holds a finite number of chunks. The amount of attention can be increased, via concentration,



controlling environment and practice. A careful initial or re-examination of sensory receptors requires an increased investment of attention.

Working space has been given the capacity of  $7 \pm 2$  chunks. The question, what is a chunk, has been posed since the designation. A variety of research has been designed to place a number on it, but for reasons previously mentioned this is not practical for real world situations because individuals will chunk and hold information differently. Without specifying exact parameters I want to say that a useful size chunk is larger than those tested for. Working Space, other than holding and manipulating, has always been considered an unshared space. It was understood that around it was an edge of impermeability whose sole designation was to maintain life. Within this impermeable skin it appears to have a shared, interlocking structure; not necessarily hierarchical. It is composed of two or three pieces of attention that can hold three or four chunks. In almost any 'chunking' task we seem to form groups of three or four, not two or five, (Jones, *et al.*, 1995). In the customary phone number example, notice it is grouped in threes and fours. In rote memory and serial list tasks we consciously and subconsciously group in this manner. We string these together in varying numbers depending on the complexity of the task. In an effort to answer open-ended questions no more than two of these groupings can be maintained. It is accepted that a portion of this consciousness deals with primarily autonomous processes and that a further portion is always involved in a number of semi-autonomous responses, i.e. walking, turning,...it is, in the end, the amount of this resource you use to monitor your current surroundings. This can range from navigating a busy city street to sitting quietly in your room with the amount of attention required varying with the demands of the task. Complex repetitive tasks can be maintained with little attention but even simple tasks in a new environment can require all of your attention. It is with these groupings of chunks that we wilfully navigate the cognitive network. In responding to a question, at least one bit is required to maintain the question, a simple open-ended question requires at least two chunks. The ability for the remaining chunks to find the answer to the question, if it exists within the cognitive network, depends on how accurate the aim of the targeting mechanism and the ease of navigation in this part of the network. The denser the network, the more often explored, the more often applied; the greater your ability to move about the network and find the answer. If

stretched too far your attention will lose its grip, either on the question or the desire to answer it.

Is attention an executive process?

Attention is the only portion of consciousness that we wilfully control. Therefore the straightforward answer seems to be yes, but I hesitate to make this designation. Not because I disagree with the general insinuation, but out of fear of being seen as in agreement with previous proposals. There have been a number of past models. I found good in many of them and still see the pieces of my own model couched in the language of different proposals. But we have an innate tendency to think that, if an instance of disagreement is found in a proposal or model, it should be scrapped in its entirety. Often the impetus for this throwing out is having a clean table on which one can present one's own model with its own language which advances it as special and different and the credit therefore to it, generally unshared. My proposal is held at arms length to prevent the unnecessary and confusing defence of it as a whole, in light of perceived agreement with portions of previous proposals. It is accepted that a complex structure will require the effort of many tradesmen under the diverse banner of cognitive science.

The question to be addressed is whether attention is a singular entity, or has a single master, personal will. The answer is simple, yes and no. Yes, in that sheer force of will can marshal attention's available resources to a single purpose. No, in that the subconscious takes in all available attention, and the ability to suppress semi-autonomous actions to a zero demand is not possible.

Attention is the collective, conscious and subconscious, strumming of the sensory receptors. This appears to be the case even when our conscious goal is wrapped in the theoretical. Despite the constructs being formed almost entirely devoid of sensory stimuli, the background and edges of our focus relates the constructs directly and indirectly to personal (sensory) experience. This orchestrated event is the driving force of the mind, though the relentless drive appears to be the desire to wander (dream, fantasise). Even when trying to concentrate, the subconscious will intervene. The subconscious is a low level drive whose strength is in its volume of attention and the novelty of association. It breaks in on consciousness when it gathers enough



volume. The subconscious flows across the database, directed by its own desire, but knows no more than the conscious mind. If it comes across an unusual conclusion, the novelty of it attracts more attention for processing and thus breaks in on the conscious self. It is understood that the local environment demands a portion of attention and, beyond simple concentration, the ability to control this demand is best served by altering the environment.

It is an engaging question to consider what subconscious attention is interested in. That portion is always prevalent and always occupied in its own exploration, which is never in direct concert with conscious attended exploration. Does it have intention, or does it merely react to the stimuli it finds? It may be surplus energy (not consciously used) operating on the field on which it finds itself. There will always be leftover attention, kept in reserve to address emergencies. When not sounding the alarm it may behave like a newly released dog in the park, running about sniffing anything of interest. Though not with the same purpose, this hound of surplus attention: will sometimes follow the previous paths of its owner, at times, a well trodden path. On occasion it ferrets out information not found during conscious exploration. This bone of contention, it proudly drops at the feet of conscious thought.

Even an unsuccessful attempt to match a query leaves the database twisted and contorted. It is poised in anticipation of the missing link. This link may be completed while engaged in other endeavours.



*In summary, conscious attention operates on our cognitive database (Long Term Memory). The cognitive database is constructed over time, built on simple associations. As the local structure grows it expands and then consolidates with understanding. Sensory stimuli are the initial and continuing data collected. As data accumulates the stimulus becomes, in part, theoretical in nature. These theoretical constructs, much like sensory stimuli, may remain comparatively under-developed without effort.*



*A targeting mechanism frames the question; and reframes, and reframes,... This query is stretched across the cognitive data-base. The accuracy of the contact is proportional to the amount of dedicated attention plus the familiarity with the cognitive network. Associations within the cognitive database are explored within a restricted number of steps. This process is to some extent dependent upon the amount of attention that can be supplied. Increased attention is a secondary player here with no amount of focus compensating for familiarity. Sometimes we can't find the correct answer because we asked the wrong question. A reframed question may bring together different data bits or provide an alternative arrangement of the current bits. This demand on attention is a funnelling down which continually draws supply from the top. Therefore, attention must be concentrated at one level to explore the next.*

*Attention is a portion of consciousness, over which it has significant impact but not complete control. These portions of attention can hold three or four chunks of information. Great effort is required to hold more than two portions at a time. The ability to focus attention may be practised and improved. The improvement is a total gain from a number influences of which we have limited control. The overall ability is no doubt genetically regulated.*

*\*\*So, that is attention;*

*it is what you are using,*

*or is it, what is using you?*

## Chapter Two

### *Concept Maps*

We are walking talking accumulations of our experiences. In fact, it is scientifically proven that we begin this associating, discriminating and filing process long before we can walk or talk (Trevarthen, 1978). Young children are animate sponges with each new experience absorbed into their ever-changing ever-growing cognitive network of neuronal connections. This knowledge is collected and applied to understand and modify their environment. We learn the word dog and every animal becomes a dog. The inappropriate uses are corrected and we learn to discriminate, some of the dogs are cats. This is the start of concept formation, where we group like things under a more general label. But how do we establish the distinguishing characteristics? These parameters vary with every case, sometimes size, sometimes shape or colour. This is a complex process that can be correctly applied without the ability to fully articulate the parameters. Ask the young child why the small delicately featured dog is not a cat. If you generalise the responses and continue to probe the child will quickly concede the verbal battle, but it is still a DOG!



Concept formation is the backbone of our cognitive database. As was discussed in Chapter One, we chunk information for the purpose of holding more within attention; concept formation is a form of chunking. But these labels are not isolated chunks, and a multitude of examples are attached to the concept. The parameters of the concept are contextually dependent and constantly amended. For example, you are walking through a residential neighbourhood consciously going over your shopping list. As you walk along, you negotiate the pavement, kerbs, and people. There are cars moving down the street and cars parked on your right, stairways, trees and a variety of potted plants to your left. All of these things are on the periphery of your attention, moving through sub- or semi-consciousness. Yet, what's this? Four blue doors in a row! There is nothing unusual about the doors, nothing unusual about a blue door. You were unaware of even noticing the first, or the second, or even the third. The implicit parameters in this context required a random distribution of acceptable doors. You stop, look back to verify and to see if there are any other similarities. Finding nothing more interesting it is accepted as a curiosity and your concept of doors will not change. The significant point here is not the fact that something unusual or unexpected breaks into consciously attended thought. What is interesting is the first three doors, the ones you were not even aware of noticing. It seems obvious that we subconsciously process stimuli at various levels testing the current parameters (contextual boundaries). Without even trying, we accumulate, associate, compare, and contrast incoming stimuli. The results of this analysis may, in general or in context, alter concept parameters.

If our mental machinery works so easily and so well, why do students find school so difficult? *It must be the nature of the material, semantic versus episodic information.* No, if we read an interesting book we find ourselves looking through the hero's eyes as we go about our daily routine. How would d'Artagnan have interpreted or reacted to this situation?

*It must be the way material is presented.* This is partially true. Here we encounter the difference between the teacher's top down, and the student's bottom up, perspective. The teacher, having already learned the concept, provides the label, a precise definition and specific parameters which tend to be carried by the negative rather than the positive instance. In other words, the teacher tries to convey the edges or

boundaries of a concept. After memorising the rules the student should have no trouble understanding or using the concept. But concepts are developed along a continuum, data – fact – concept – generalisation – theory. Each component of the continuum has some subordinate or hierarchical relationship to the other components. Data comprise the fabric from which cognitive phenomena evolve. Facts are a component of a concept, representing the perceptual flow that an individual generates from data. Fact clusters in a special interrelationship then form a concept. Concepts are emergent, they come into being from a network of inferences based on past and present experiences. Prior to the initiation of the network, concepts are non-existent. If in the learning of a concept all of the relevant subordinate concepts are not learned, the student may be able to list some appropriate facts or examples without truly understanding the concept. Without true understanding this acquired information is not merged into our usable database. It remains isolated, reserved for appropriate regurgitation to answer a test question.

The primary reason academic learning is difficult is the passive role the student is required to accept. Students are told to sit down and be quiet while the teacher pours knowledge into these ‘inanimate’ vessels. Teachers are satisfied, in fact delighted by students who passively record and then, on demand playback their words of wisdom. Information can be transmitted, but knowledge cannot. As previously mentioned, we are accumulations of our experiences and the structuring and understanding of these experiences is as individual as a fingerprint. In order to learn we must receive feedback to our individual queries at our own pace. Teaching means creating situations where cognitive structures can be discovered. It does not mean transmitting structures which may be assimilated at nothing other than a verbal level.

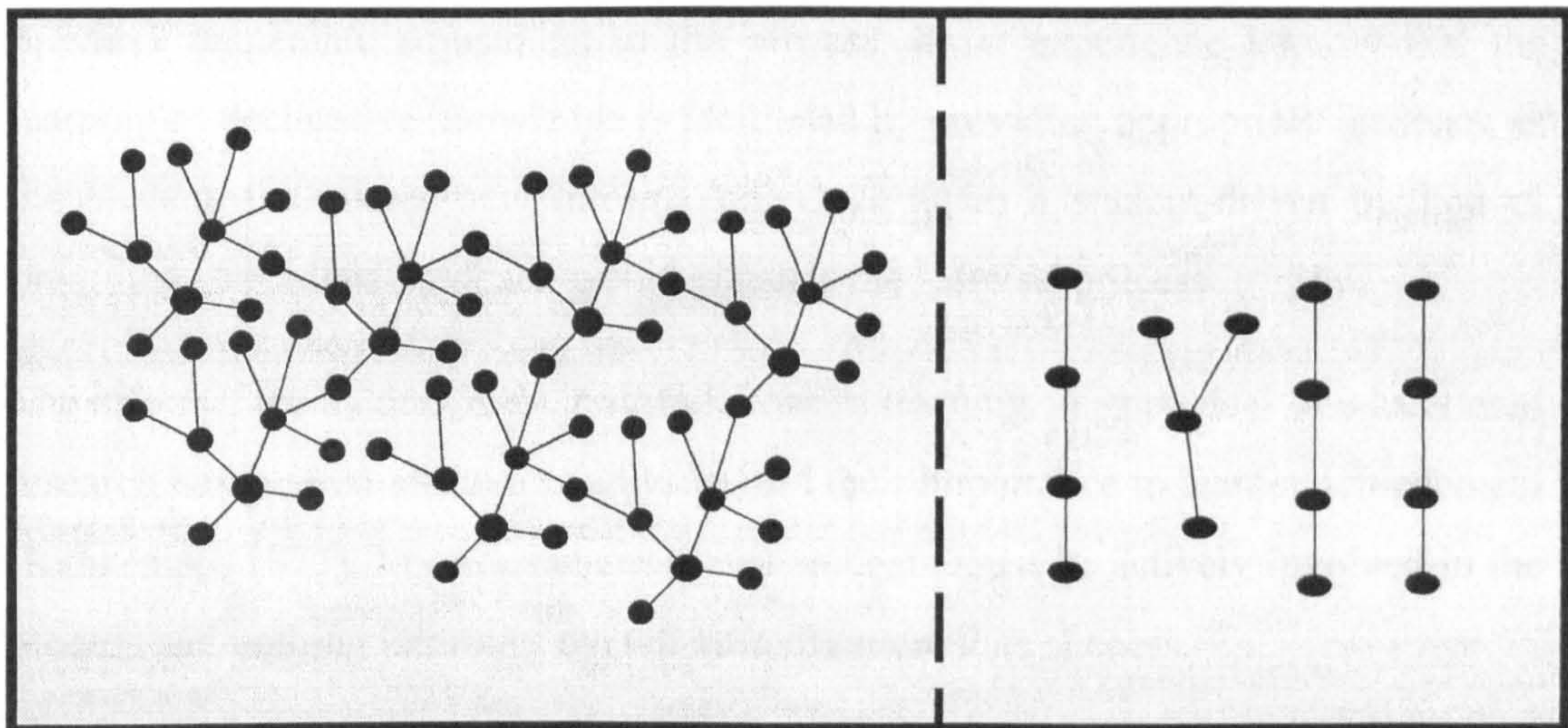
In academic institutions, it seems that we, educators, are our own worst enemy. We must find a way for students to utilise the accumulating and assimilating of information that comes so naturally in their personal life, Fig. 2.1 (page 28).

Vygotsky (1978) identified two levels of concept development; spontaneous concepts, learned through direct sensory experience and scientific concepts, learned through language. He then described the power of scientific concepts; they are systematic, can be applied to different contexts, translated into awareness and control of thought.



The difference between spontaneous and 'scientific' concept development is a matter of levels, but I don't know that the power resides with the scientific. As described, the scientifically developed concepts are learned through language and therefore have been previously abstracted. Each layer of abstraction loses fidelity and in many ways loses power. The personal aspect of spontaneously formed concepts cannot be communicated fully. Spontaneously formed concepts most definitely can be applied and they are developed by the system they must fit. Spontaneously formed concepts naturally fall into place within our personal system. The scientifically formed concepts must take a step backward before they can appropriately be projected forward. The ability for students to accept (learn) the system in which concepts are academically presented may be as great a difficulty as learning the concept. It may very well be that we struggle with the placement of scientific concepts until we can amend them with the background and peripheral information that they lacked.

Traditional education, at best, produces thin columns of content specific knowledge. This structure is totally unsuitable for application of that knowledge to open ended, real life problems. The term 'problem' is used here in a general way denoting anything not clearly understood. It is not always intended as finding the solution to a Sherlock Holmes mystery.



**Figure 2.1 The Cognitive Database (proposed schematic)**

The left side depicts our highly integrated cognitive network, this is the database that we utilise in everyday life. It is densely packed and associatively rich. The right side illustrates the isolation of academic learning with its primarily linear configuration with little branching.

Each learner is unique. Traditionally this has meant that teaching has adopted the method with the widest general appeal, therefore obtaining the highest combined



outcome. This path was chosen because the perceived alternative was seen as applying a specialised teaching method tailored for each learner, and this was not possible. So what do we do?

The goal of the teacher is clear, we must examine the role. The teacher should facilitate learning. The learning objectives may be the same for all learners, but the methods of obtaining them can be as varied as the learners themselves. Individual learners have their own knowledge base, disposition towards learning (affect) and 'problem solving' learning strategies. A student-driven method of learning would have a positive impact on the academic process by improving student understanding.

There are two overt forms of knowledge, declarative and procedural. Declarative knowledge is one of detail, definitions and specific facts; procedural knowledge is a 'how to' list. Together these two forms of knowledge comprise the database on which the learner operates. Traditional education has tended to favour declarative knowledge almost to the complete exclusion of procedural knowledge. Cognitive scientists have tended to view these two types of knowledge as being acquired, stored, and utilised, in very different ways. However, both are built up through personal experience, filed contextually, and composed of bits of sensory stimuli. The difference is that procedural knowledge has a built-in feedback mechanism that provides immediate adjustment to the process. From experience I know that the learning of declarative knowledge is facilitated by providing appropriate feedback as the student assimilates new information. Once again a student-driven method of providing immediate feedback would enhance the learning process.

The affect of the student is their attitude toward learning. A great deal of educational research has centred on student attitudes and their importance to learner achievement (Kahneman, 1973). My assessment is that students must be actively involved in the process and nothing improves overall attitudes more than success.

## **2.1 Mind Maps and Concept Maps**

Thinking skills instruction has tended to be implicit rather than explicit. The results of a process are presented without an explanation of why a particular process is chosen or why it works.



Information processing with its manifestation into current theories of learning and its practical application to academic and real life performance is important to educators. But it is through an awareness of these processes that students can be encouraged to become metacognitive participants in their own learning process. The passive role of information gathering can be replaced by an active self-regulating strategy as metacognitive abilities are improved.

Several attempts have been made to represent cognitive structure graphically. The association theory, entailment structures, frame systems, mind maps, concept maps and various networks all stem from computer based models. Two of the most popular, due to their reported practical application, are the Concept Map first developed at Cornell University by Novak (1979) and Buzan's Mind Maps some five years earlier (Buzan, (1974).

In general, concept maps and mind maps are a non-linear representation of facts and concepts. A central idea or key concept is selected, related facts or concepts are then placed around or under the key concept connected by lines. This branching pattern of related concepts is repeated forming an interconnected network of ideas and concepts describing the key concept.

Buzan (1974) guided his followers through map construction highlighting individuality and creativity. He used colour, symbols, drawings and an overall layout appealing to the different hemispheres of the brain, as well as different learning styles.

My differences with Buzan's style of Mind Mapping are three-fold; commercial appeal relying heavily on process, focus on an artistic end-product and catering to the exception rather than the rule, each of these are discussed in turn.

Buzan has written a number of books and has given many lectures extolling the virtues of his process. He takes his audience through more than a dozen steps with explicit instructions for each one, i.e. use different shapes to differentiate nodes at various levels, adjust connecting line widths to designate strength of association or importance.

He advises using colour, symbols, drawings and sweeping lines to enhance the final appearance; a map on thinking may take the form of the brain, while one on botany may look like a tree or flower. This style shifts the focus from learning to a stand alone work that relies heavily on existing knowledge and exploits creativity and artistic ability. Creativity and artistic ability vary across the population and are significant attributes to be nurtured. But they do little either to enhance understanding or foster learning of the concept being addressed.

Buzan has anchored the Mind Mapping process on idiosyncrasies. We are all individuals and have our own learning style. Our learning style is the result of cognitive preference and was the centre-piece of research in psychology some years ago. Different learning styles do exist and for some individuals with a particularly strong cognitive preference the presentation of material in their style dramatically affects learning. These are the exceptions not the rule. Nearly 75% of us are quite happy dealing with the written word followed by 12-15% preferring a pictorial presentation, some 6-8% gaining through an audio approach, the remaining 3-5% seeking inspiration through the bottom of a pint glass (Bower, 1978). Buzan's Mind Maps target individuals preferring a pictorial presentation and cater to this style so strongly that those with other learning styles are disadvantaged.

For Novak (1984) Concept Maps represent meaningful relationships between concepts in the form of propositions. These propositions are concepts connected by words in a semantic unit. This means that a properly constructed concept map could be read as a series of sentences describing the concept. His stress on the linking words; is, for, contains, breaks down, eats,... he claims adds additional meaning and precision to the concepts being described. I disagree because these linking words are modifiers and are therefore constraints on the concepts being linked, and as such can not supply additional meaning but only limit it. I do not deny that these modifiers are implied in a concept map created without them. But what these maps lack in developing precision is more than compensated for by allowing greater freedom of exploration unfettered by constraints of precise association or syntax.

Despite the title 'Learning How to Learn' and various internal references to the same, I found little in Novak's book aimed at the learner or even at the process of learning. His book and his process is aimed at the educator, researcher and administrator, not



the learner. The primary goal of his Concept Maps is assessment. Use them to evaluate the students current knowledge base, compare before and after maps to evaluate learning, use as an alternative form of final assessment of the students' knowledge highlighting a hierarchical examination of links and concepts. To be fair, Novak did exhibit some discomfort in quantitatively scoring concept maps for reasons of idiosyncrasy. He then proceeded to construct or refer to various methods of quantitatively evaluating the maps.

## 2.2 My Concept Map

Much of the philosophy behind the work of both Buzan and Novak is sound. In both cases, the ideas were pushed beyond their most useful application. Buzan, in an effort to have a unique product, and Novak, in an effort to appeal to the educator rather than the one being educated, created a process of limited use and appeal.

My Concept Maps are aimed at the learner *during the learning process*. They are metacognitive learning tools, the precise application of which varies with every learner.

To use 'Aristotelian logic', I could certainly do worse, "Only man has active recollection and constructive imagination (as employed in art). The imaging function is as necessary to thought as sensation is to imagination. By the productive imagination the necessary schemata are supplied to reason." Ignoring Aristotle's claim that this ability is purely human, I could not have stated the rationale behind my form of Concept Mapping better. The driving force however, was my perceived reality that much of educational research seeks only to reduce its cruelty and wastage by predicting who will survive in schools as they are. They take the system for granted and try to identify who will fit into it. I am trying to develop a process that learners can use to enhance their personal learning abilities regardless of the system in which they find themselves (Fig. 2.2).

A map is a useful guide to where we are or want to go. Most introductions to concept maps or mind maps begin with this or similar statements. The inference is clear and the process produces an image that contains paths and intersections with apparent signposts. But the major benefit of concept mapping is the concurrent changes in

cognitive structure during their fabrication. These changes are only partially transferred to the map.

What are the rules for concept mapping?

- ◆ turn paper to landscape position
- ◆ place the key concept in the middle of the page
- ◆ around the key concept randomly place directly related concepts (level 1)
- ◆ connect each of the level 1 concepts to the key concept with a line
- ◆ expand each of the level 1 concepts to directly related concepts (level 2)
- ◆ continue to use lines connecting direct associations
- ◆ this process is continued from level 2 to level 3,...
- ◆ as each concept is expanded its relationship to the key concept is maintained

General instructions –

- ◆ It may be helpful to enclose concepts, in a circle, square,....
- ◆ Use colour, symbols and drawings when you deem appropriate.
- ◆ Try to expand map one level at a time.
- ◆ Try to limit each node to a single word or two.
- ◆ The amount of detail explicitly shown is dictated by what you find helpful.
- ◆ Most importantly this is your map, so apply the rules and instructions in the manner that feels most comfortable.

**Figure 2.2 Rules for Concept Mapping**

These are my rules loosely adapted from Buzan, Novak and others. I am hesitant to refer to them as 'rules'; they are really suggestions.

The key concept selected for analysis can be a single concept (pH, plants), or it can be a scenario composed of many concepts. The paper is turned to landscape position with the key concept placed in the middle for two reasons. First, to allow more room for expansion. Second, to take advantage of the brain's natural tendency to chunk and link information. When we describe an idea or an event, we do so by selecting relevant information in a hierarchical fashion and expand with pertinent detail. This selecting process is personal and rarely follows chronological order, nor does it necessarily flow in storybook fashion. The random placement of concepts encourages the break with the traditional linear representation.



The concepts may be enclosed in boxes or circles and are connected by lines to help the learner focus on the particular association being examined. While each association is examined individually its ties to the key concept are preserved. The nature of a particular association differs depending on the context in which it is applied. Colour may be used by some learners to highlight the continuity of a specific branch in the map.

Stopping short of Buzan's over emphasis, it is undeniable that a significant attribute of concept mapping is their visual appeal. Whether this appeal is actually to different hemispheres of the brain or just different forms of processing does not matter. The old adage 'a picture is worth a thousand words' has some relevance. The manner in which we record visual stimuli means that the image is recalled as a whole. Whether this recalled image is worth a thousand 'meaningful' words depends on understanding. For the same reason symbols and drawings may be used within the concept map.

The suggestion that the map be expanded one level at a time stems from research on information processing. It was proposed that memory traces are strengthened by the number of times they are activated, not the length of time activation is maintained, (Naumann *et al.*, 1992). This switching of attention also keeps an individual from expanding a single branch of the map three or four levels without considering the potential influence of indirect associations.

It could be argued that individual learning style and the degree to which the concept is understood will dictate the amount of detail found in a concept map. A map of newly covered material will contain far more detail than one reviewing a well understood concept. Limiting concepts to a word or two is partially related to the notion of detail. Concept Maps should prompt the mind. They are not intended as an excuse to write down everything you know. Some effort should be taken to reduce the amount of explicit information. This helps you to remember more. In addition, the overall layout of the map is enhanced when branching patterns are easily seen and followed.

Beyond accepting, at least in part, the philosophy upon which they are founded and the basic process, by far the most important instruction is that concept maps are

personal. They are a personal learning tool; the rules and instructions should be viewed as guidelines and applied solely at the discretion of the mapper. This personal view not only makes the process more comfortable but more important, psychologically. When we are allowed to choose, whatever avenue is taken is done so with more conviction. A sense of empowerment comes when students discover they have the ability to gather information and deal with their experiences as they struggle to understand contexts, structures and relationships. Dewey (1933) suggests that there can be no true growth by experience alone, but only by reflecting on experience.

Tulving (1983) stated, 'recollection of an event, or a certain aspect of it, occurs if and only if the stored properties of the event are sufficiently similar to the properties of the retrieval information'. I am in agreement with this statement if one allows the internal manipulation of encoded stimuli, not only at the time of encoding but also during subsequent analysis. This manipulation will broaden the range of 'sufficiently similar' (stimuli). I am in disagreement if one believes, there is no substitute for experience and the only way to retrieve the correct answer is to have encountered the question previously. My information processing model has already indicated that thoughtful reflection can broaden understanding and therefore broaden the range of stimuli to which it will respond.

Emergence of a solution to a problem (question) requires first an accumulation of acceptable constructs about the problem. This is followed by a unifying insight that relates all the constructs to each other. Insight is the point at which all of the pieces fall into place. This moment of insight, 'eureka' point, cannot be reached without all of the appropriate pieces. Educators who focus on this moment of clarity have forgotten or downplayed the substantial effort taken to reach it.

The ability to use knowledge in a productive manner must be learned in repeated, guided practice and be directly related to content. If, and only if, the learner is the guide and personally determines what is directly related, will this deliberate process produce richer associations in memory. With learning dependent upon existing knowledge, this is a cumulative process. The conceptual frameworks developed during the process tend to remain in memory and be easily recalled.



Why is personal control so important to the learning process?

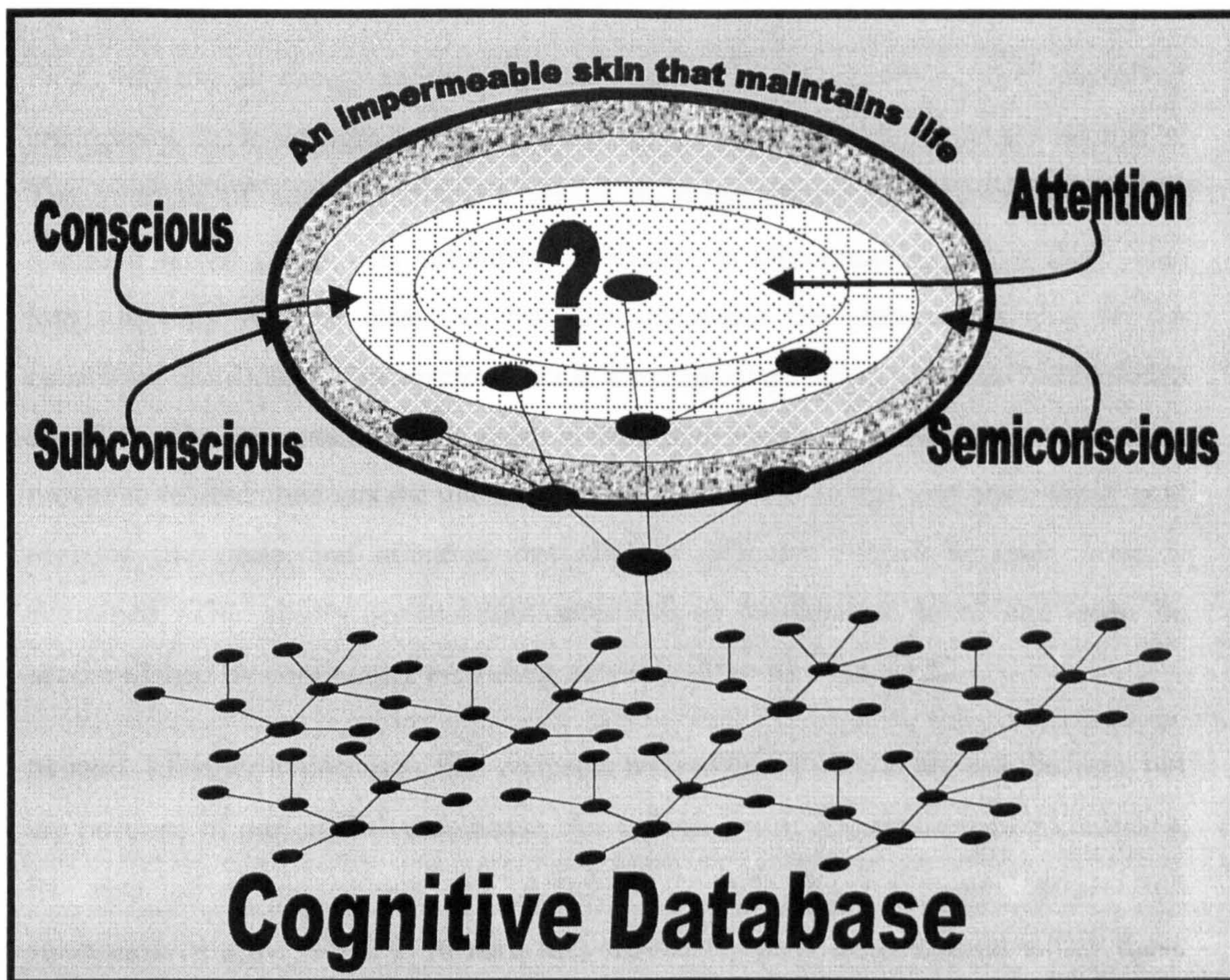
Imagine that you hand a chemist and a physicist an unknown substance and ask, what is this?. Both scientists would proceed in the same fashion. They would record the mass and the general physical characteristics. Then they would divide the sample into portions so that multiple avenues of analysis may be pursued without fear of an unrecoverable altering of their starting point. From this point forward their methods would be markedly different. In general the chemist asks the question, what is it composed of? What are the individual components?. The physicist asks, what does it do? How does it react to various stimuli? In a similar length of time both scientists will return with the correct answer to the question, what is this?. At that point both can comfortably discuss with one another various attributes, solubility, conductivity and so on. If you had intervened during the process of analysis and required that they perform the same tests in the same sequence, neither scientist would have been happy. They would have argued over the approach, culminating in a compromise that left neither satisfied. Forcing them to utilise someone else's conceptual framework would have reduced their understanding and initiative.

One might argue that the different approaches preferred by these scientists is a result of their academic training. Certainly true, but the decision for one to pursue chemistry and the other physics was just a further expression of their individuality. Information can be transmitted from teacher or text to learner but, knowledge can not. Knowledge is personal! In the constructivist epistemology, teaching/learning uses as its starting point the student's existing knowledge. 'The final outcome of learning may (should) not be a solution, but an analysis of the situation.' This analysis, and indeed learning is not active addition of information but merely the rearrangement of existing knowledge.

All cases of contact with the cognitive network is framed in the context of a question. The targeting process described in Chapter One is our access to our cumulative database. At times the question is sufficiently abstract so as to allow a rather open exploration and in other cases is strict and succinct requiring a specific response. In either case the precision of the targeting process is improved only with practice. To some extent this is the ability to frame the pertinent points while ignoring the irrelevant ones. This has been described as the ability to separate the signal from the



noise. In some cases this is easily understood, where obvious distracters so muddle the picture that a clear view of the problem is not possible. However it is not always easy to decide what is signal and what is noise. In fact the delineation between the two may vary from one individual to the next. Even when there is no noise to be eliminated the targeting process has decisions to make. The particular way a question is framed will depend on the quantity and quality of information in the database being accessed. Familiarity with the database not only improves the ability to move around it but also increases the precision of the contact. Knowledge is not the answer to the question, but the ability to arrange your personal database to answer the question.



**Figure 2.3 Using the Mind**

The targeting process forms a question, therefore accessing the cognitive database. As an individual portion of the database is examined, its associations are stretched through the conscious, the semiconscious and the subconscious.

Attention is the only portion of the mind that we can control. If we have reduced the demands of our immediate environment and focussed our attention on a problem, then all of our available resources are brought to bear. Within the model this enlarges



attention to its maximum, reducing conscious thought on other than the problem in hand to a minimum. This has little, if any, impact on the semi- or subconscious. While we are aware when distractions enter into attended thought, the demarcations between consciousness and semi- and subconsciousness are less tangible. This is because the distractions of seemingly random thought, or awareness of environment, travel a continuum and are not identifiable until they reach conscious thought. Despite being unrecognisable, the fact that they are bubbling away below the surface is undeniable. They monitor and make sense of their environment, that is the environment perceived through the sensory receptors and the environment created in the mind. I contend that in this way they, conscious, semiconscious, and subconscious, affect attention in two ways.

First, they use all energy available to them and while, except for cases of perceived emergency, their strength is less than that of attended thought, they are relentless. The strength of attended thought begins to wane almost from inception and if attention is not continually refocused its energy is incrementally diminished. This loss not only reduces attention, but also increases the energy available to the conscious, semi-, and subconscious mind. Concept maps serve continually to refocus attention. The key concept or problem is the initial focus, or question. As the student moves to related concepts the question is slightly altered. In this way the overall goal remains the same, but attention has slightly different stimuli as each node is examined. The ability to maintain attention at its highest level can only be accomplished by continually providing new stimuli to be examined.

Second, I further hypothesise that concepts held within attention are not discrete, but are portions of our cognitive database. As a single bit of this network is attended to, its associative connections are stretched through the conscious, semi- and subconscious mind, Fig.2.3. In part, this creates the environment upon which these portions of the mind operate. Concept mapping provides an array of relevant associations for these portions to process. The potential for these parts of the mind to offer distraction is inevitable. However, if attention is continually focused, this peripheral processing may implicitly enhance understanding and navigation of the database.

How far does superior vividness and fidelity in imagery from one sense go with inferiority in other sorts of imagery? To what extent is motor ability a symptom of intellectual ability? Does the quick learner soon forget? What are the mental types that result from the individual variations in mental functions and their inner correlations?

It is my opinion that science has addressed these questions and the conclusions have been interpreted as absolute truths. These conclusions are tendencies rather than truths, but more importantly they can be adjusted and modified by personal awareness and reflection.

## 2.3 Teaching Concept Mapping

Both the selection and placement of concepts to be explored is highly personal. Any attempt to teach the concept mapping process will tend to focus on these highly subjective points. Most efforts to teach concept mapping have taken the shape of a group or co-operative process. This approach reduces the oppressive force of teacher presented material and increases the likelihood that peer selection will more closely resemble their own. But, the ultimate distraction of not being personal remains to varying degrees. A collaboratively formed map is a composite that may be understood by all of its constructors but doesn't mirror the particular connections of any one of its creators. A collaboratively formed map does serve a purpose. It is a check or assessment of collective understanding, which is useful to the teacher (establishes a general platform of understanding), and for the individual to compare their personal knowledge with that of their peers. It is an appropriate group (general) platform on which to plan further exploration. Actual learning is restricted to a more personal approach. What is personal is not only the direction but the speed of exploration. It is possible to see a connection (an association) in a group map that produces a cognitive connection in your own network. This should be a secondary process, not the primary use of concept maps.

If training in concept mapping follows the normal design of being a stand-alone process, even when the subject of the map is the current topic of study, the concept map will be seen by the students as a time impediment to proper study of the subject. The process must be seen as a tool, a means to an end, not a detached endeavour.



Improvement (utilisation) of mapping skills has always been seen as the subjective improvement of assessed maps, but they are a learning tools not a subjective skill to be analysed. The ability to display mapping skills effectively is separate from the ability to use them effectively. The difficulty is in getting teachers to accept this fact while still promoting their use.

My concept maps are aimed at the learner, during the learning process. I am much opposed to using them as another mediocre form of evaluation. Evaluation of someone else's concept map is highly subjective. If the maps are evaluated qualitatively you make one subjective judgement. If you evaluate it quantitatively the map is exposed to multiple objective evaluations, objective only because the evaluator didn't subjectively make up the rules.

I suggest that concept mapping be introduced to students as part of their regular curriculum and that it be reinforced by teacher interest, not intervention. The teacher should assume that the students regularly explore their academic cognitive network and should refer to it in a general way, always stopping short of referring to it as separate from their normal study routine.

It would be a normal occurrence for students to continue to say that they may use maps in the future and then for the actual amount of mapping done to decline. The process does require positive reinforcement for it to become established.

In order for students to adopt the strategy, they must see it as having practical application to their regular routine. They must see it as an effective study strategy in the long run, not too long.

The teachers must learn. This is not a procedure to be learned by the students. They already were investigating, visualising and organising information before they could walk. What must be learned, by the teachers, is that this natural process is appropriate for academic endeavours. Their assistance and encouragement is not only beneficial but necessary in developing this natural ability.

Students focus on information gathering and analytical metacognitive processes within the academic environment. They construct meaning (knowledge) and in so

doing explore personal abilities (methods) for building an understanding of life-long learning skills.

## 2.4 Using Concept Maps

Now that concept maps and methods of introducing them have been discussed, we must ask who can use them and what can they be used for?

Despite an avalanche of criticism from educational psychologists, Piaget's theory, (Piaget, 1926) of cognitive development retains much support. This theory indicated four stage of development:

- (i) sensory motor, pre-reasoning responses – ages 0 to 2 years,
- (ii) preoperational responses, interpretations of tangible objects or events on the basis of manifest attributes as perceived by the child – ages 2 to 7 years,
- (iii) concrete operational responses, responses based on reasoning, but only about manifest attributes – ages 7 to 14 years,
- (iv) formal reasoning responses, 'abstract' thinking about objects or events – ages 14 years and above.

If Piaget is correct in suggesting that abstract thinking cannot occur before the age of 14 years it would appear that concept mapping should not be introduced before that time. However, in many ways man is a collection of exceptions not of rules. By placing a rigid delineation between the stages, Piaget was begging for a fight he could not win.

What Piaget could not have anticipated is that almost from the time of writing, western society began to change. In every home the hum and glow of tubes began to invade. With the flip of a switch the quiet of home-life was replaced by an ever expanding tide of audio and visual stimuli. For those over 30 years this deluge of information can seem overwhelming. What has it done for children growing up bombarded by radio, television and computers? A number of sociologists are concerned that it has provided too much entertainment for too little effort. Perhaps they have forgotten the words of their youth, 'the times they are a-changin'. Dylan's words were not an expression of the Sixties but an expression of youth. What our media rich society has done for children is to provide them with far more information to process. Compared to their parents, their language and information processing



skills have evolved much faster. This doesn't make them smarter, but if assessed in Piaget's interview style, they will display a verbal sophistication far beyond their years. This may actually increase their need for a thoughtful assimilation of this immense volume of stimuli.

Concept mapping is a useful tool for anyone whose writing skills and vocabulary are sufficient not to be overtly obtrusive to the process.

### 2.4.1 Concept Maps for Planning

Concept maps are ideally suited for planning. The organising and arranging of multiple pieces lends itself to this open strategy of selecting and exploring.

Teachers will find them especially effective for planning their lesson, whether it is a single meeting or the lesson plan for the year. If you are looking at the entire year, select the main topics then break these into their components. The number of components attached to a main topic may provide insight into the number of class meetings necessary to cover the topic. These expanding branches can be evaluated and matched with the required outside resources. This composite overview also provides an opportunity to see that assignments are judiciously spread across all of the topics covered.

Concept maps may be used in concert with the written word. Most people find a writing assignment a daunting task. The psychological linguistic manipulation of ideas requires a great deal of attention. The finite resource of attention can be practically exhausted by this manipulation leaving little, if any, room for the selection and ordering of ideas. So, whether writing a brief essay or a book, a concept map may be a useful starting point.

Begin by selecting the major topics you wish to cover, and later these can be converted to paragraphs, sections, or chapters as needed. Each of the chosen topics can now be expanded being sure that all of the pertinent points have been covered. Only after gathering all of the pieces should you go back and think about the order in which you wish to present them. You began this task with an internal notion of how you would present the material. The concept mapping process may provide some surprises. Because you already understand the ideas, you may find that you had

skipped over material that needs explaining or were not presenting ideas in an order appropriate for someone who is not familiar with the material.

## 2.4.2 Concept Maps for Study

In this section, using concept maps, I have previously and will subsequently discuss a number of helpful applications of the concept mapping process. But their application to this area (the learner during the learning process) is what sparked my interest, my imagination, and my effort. This is where memories are explored and knowledge is constructed.

The typical study process of students is a serial examination of concepts that is devoid of exploration and therefore fosters little branching (lack of opportunity for integration). This serial examination takes the form of holding data chains of varying length within the working space. In the character of rote memorisation the process attempts to file these chains so that they can be recalled at the time of assessment. Students have two cognitive choices in memorising these data strings. They can hold the pieces together with semantic flow like memorising prose, or the condensing of their cognitive structure through understanding. The lack of meaning in these data chains increases the difficulty in holding them and without understanding, the ability to condense the information is constrained. The repetitive process of serial examination has the ever-growing difficulty of holding interest. Attention does not follow the line of intention but a line of interest. Our cognitive machinery quickly diminishes the volume of attention allowed for repetitive events. Maintaining interest, in difficult to hold, rather meaningless serial lists, is not easy and follows a path of diminishing returns for time spent 'studying'. It is most definitely not the quantity, but the quality of study time that improves performance.

After new data and facts have been gathered from texts, lecture notes, and outside readings they must be assimilated. The student should select a key concept that will encompass all of this new information and then proceed with the mapping process as previously described. During the mapping the student should strive to recall and appropriately apply all of the new information gathered. The map should prompt the mind not be a record of every step they take. Their notes and texts should be at hand but not the primary focus. The initial effort is to recall and only upon reaching a sticking point, are the notes and texts used. How quickly a student reaches for



support will to some extent depend on their individual learning style. What they should not do is construct their map directly from the text and notes. Remembering and understanding requires some effort. Trying to recall organises and prepares the cognitive network for the anticipated link. This type of mapping is an intimate conversation with yourself. Contrasted to other uses where you stand back casting a net and then examining what is dredged up, in this form of mapping you literally crawl down into your memory traces and not only explore but construct them. For this reason these maps may have an unusual appearance in that they are a mixture of broad concepts and finite detail as learning occurs. Concept mapping is an elaboration of knowledge which many educationalists have determined is needed for learning (Anderson & Reder, 1979). According to Reder (1980), elaborations provide redundancy in the memory structure. Redundancy can be viewed as a safeguard against forgetting and an aid to rapid retrieval. This 'redundancy' might be viewed as a node created on the cognitive network and then absorbed into the layer from which it grew. As you progress through the map you are actually reinforcing the layer behind the one you are exploring. It can be argued that it is the act of condensing knowledge that advances learning. These maps are an intimate echo of what is happening within the mind and once completed are of limited value even to their constructor.

### 2.4.3 Concept Maps for Taking Notes

Students spend a great deal of their academic life taking notes. Beginning in primary school, they record what their teacher says or what is written on the board. This provides an opportunity to improve listening skills, vocabulary, spelling, penmanship, and writing speed. It only indirectly and very inefficiently helps them to understand the topic of discussion. Nevertheless, by the time they reach University, most students are deeply entrenched in this style of recording and in many cases gauge what they learned by the number of pages of notes they recorded. Yet, predominately the stimuli come in through their eyes and ears and out through their hand stopping nowhere in between.

A rather loose, free-form method of note taking the final appearance of which mimics a concept map is possible. For many students, this process can be used to great advantage. For all, it has some positive attributes.

It frees one from trying to write every word the teacher presents; less writing, and more watching and listening, will provide the student with a better understanding of the material covered during the class.

Let's examine the stimuli confronting students in the normal lecture hall. The 'chalk and talk' has been replaced by OHP's, slides, and videos. Material is presented in multiple forms, too often simultaneously. The attempt to monitor closely and incorporate stimuli from various inputs simultaneously maybe distracting for all. It requires, not only the focus of all available attention but then the judicious switching between partitioned attention. This continual amending of attention combined with a written recording may succeed in producing a processing overload. Teachers enter the hall with stacks of prepared notes and graphs, no longer constrained by their own writing speed. In an effort to not waste class time and to avoid an uncomfortable (for them) silence they switch from one transparency to the next at a blinding speed. A graph conveys a lot of meaning and the students should be allowed time to process the information. Videos, computer animations, pictures, and graphs are excellent methods for getting your point across and it provides the students new stimuli on which to focus. A little variety can provide stimulation for a student's waning attention, if you allow them time to get the message.

This free form method of note taking requires the student to pick out the important (key) topics. This provides a better understanding of how the pieces fit together. The detail that may be missed would probably have needed looking up for verification and completion regardless of the note taking method. This selection of important (key) points may be two fold, not only are you picking out topic headings, you are more closely monitoring the presentation. The personal preference of the teacher and likely assessment topics can be discerned, if given attention.

I do not mean to belittle the academic institution by implying that students should determine what information will be assessed and then study for the test. Students have and will continue to study for assessment. We should ask the right questions, questions that get at the learning we want regardless of anticipation.

It sometimes appears too much of a game, but some institutions offer a class on test taking called 'Psyching Out the Professor'. These classes advocate carefully



'guessing' the test questions and then concentrating your study on those; perhaps more of a social issue than an educational one.

I am reminded of time spent working in a large regional Mental Health Hospital. There were a number of occasions when I looked out across the ward and was reminded of the inside joke 'How do you tell the mental health patients, from the mental health workers? You see who has the keys.' Through slightly bemused eyes, academic institutions can appear much the same. This whimsical view does not diminish the very real difficulty in asking the right questions. A point I will not dwell on except to say, ask questions that require the application of information (knowledge), not the recollection of it.

Personal experience in the lecture hall has unfortunately indicated that most students are unable to adopt this form of note taking. Though their notes are adequate in many respects, they remain uncomfortable with the process. All of their academic lives they have equated class time with writing as much as possible. They find this habit hard to break and revert to their old style before positive reinforcement can break the cycle.

#### 2.4.4 Concept Maps for Revision

As students prepare for a forthcoming examination they spend most of their time reading through copious volumes of notes. This re-reading requires little attention and, therefore, little learning takes place. In many cases, the students are relatively unaware of what portions of the material they know and the ones they do not. Concept maps may provide an excellent means of review and revision.

Students can check their recall and understanding by preparing concept maps for each area covered during the course. The key here is to test their knowledge and focus on the areas that need work. As was previously mentioned, learning and remembering require some effort. This effort is not the process of sequestering yourself away and forcing yourself to read through volumes of notes. The only effort, which that takes, is the effort involved in keeping you from running away. In order to get stronger, the mind must do some work. I know of a number of classes where the students made up the questions for the exam. The teacher would collect all of their suggestions and then remove duplications and the questions that were too difficult.

The exam questions were chosen from those that remained. The point is, the students know what questions are likely to be asked as well as the teacher does. Why they rarely consider trying to answer some of these questions as part of their revision is unknown. This is the type of mental effort needed to learn and recall.

A concept map of a proposed exam question allows the student to skip quickly over the material that he/she knows and concentrate his/her effort where it is needed. Inability to recall information stored in memory is due to a lack of organisation and understanding. Concept mapping combines the creation of knowledge structures and a search and retrieval strategy into a single operation. The clustering of information facilitates retrieval.

### 2.4.5 Concept Maps for Problem Solving

Real life problems are multi-faceted and 'ill structured'. They are ill structured in that there may not be a single correct response and the consequences of a response may not be immediately apparent. These problems require a judicious examination of all options and their ramifications in the short and long run.

Diagnosis is clinical problem-solving. The experienced physician has reached the most advanced stage of this ability. It is likely that the method used by most experts could be called 'pattern recognition'. While this is most assuredly the method used, it is difficult if not impossible for most doctors to identify the individual steps in the process. It is described as the ability to see a pattern within the clinical presentation and move directly to a solution. The problem with this 'expert' behaviour is that 'any two points make a straight line'. It is an accepted fact that experts see patterns that are not available to the novice. This ability is not a consequence of more factual knowledge, it is most assuredly the ability to discriminate between relevant and irrelevant facts within a large database.

The use of diagnostic pattern recognition tests (DPRT's) is growing in medical education and assessment. DPRT's are being used to study the incremental steps used subconsciously by experts, as well as being developed to foster these skills in the novice. Although this process may appear to evolve in a single step, it does not. DPRT's may assess the manifest ability of the expert diagnostician, but they are not an appropriate means of developing this skill.



These 'ill structured' problems are found in all walks of life, but share a common characteristic. Those with experience move quickly to a solution but are unable to explain exactly why. This has meant that efforts to teach the process have focused on presenting a linear series of steps. Memorising the path without visualising points of contention provides little insight for the novice. Even the path can be more confusing than helpful for individuals with a decidedly different arrangement of concepts. This has led most people to believe that there is no way to teach this type of problem solving.

However, if appropriate guides are superimposed on concept maps constructed by the learner, real learning may take place. Concept maps personally constructed should form an accurate reflection, in the mind of the learner, of their knowledge base. If the concepts and personal branching patterns that lie between the two points, clinical symptoms and diagnosis, are visualised. They may form an image that can be used to develop the desired (diagnostic) pattern recognition skills.

Concept maps provide a means of analysing not only direct but indirect associations. They are a means of increasing cognitive working space; they support and organise thought but they do not do the thinking.



*In summary, we make order out of the world by transforming our perceptions into concepts. We create understanding by making links between concepts. But the perception is not always physical and the concept is not always words. A concept is an organising structure, a label, an abstraction, a condensing of many thoughts to a single one. This label continues to be an anchor that holds together all of the ideas that become linked and subsequently filed.*

*This is a student driven activity (performance), which will facilitate the incorporation of the student's personal knowledge into their academic database. The perceived structural representation would appear twisted and contorted due to these cognitive pulls, but it is only being sculpted by the personality that drives it. The denser the structure the greater the opportunity for a database match. I expect that this also has a cumulative effect on subconscious exploration. Subconscious*

*exploration adds to one's familiarity with one's cognitive network. The extent of its influence can vary widely from one individual to another; it can vary widely for one individual from time to time. I will say only that this is a positive enhancement, to varying degrees.*

*Concept mapping on data structures built by traditional education improves the integration of these somewhat isolated structures. As a general rule the ability to transfer skills (knowledge) around such a structure is unlikely. It is hypothesised that a student using the concept mapping method in a traditional environment will progress through the academic ranks as their more familiar, more integrated, more condensed database yields better performance. Concept maps work by offering first familiarity and second the condensing of the structure. Since concept mapping is personally led and concurrently assessed it will tend to incorporate academic and social learning.*



## Chapter Three

### *Problem-Based Learning*

Pressure to cover more and more content in often overcrowded courses means that less, if any, attention is given to helping students use knowledge in creative and constructive ways. One of the most consistent and frequent criticisms of higher education is its failure to make these elements more overt, in course aims and objectives, in day to day teaching and in assessment. Unless these concerns are addressed in practice as well as theory we will continue to produce graduates overflowing with knowledge with little or no idea how to use it.

For over 100 years the sheer volume of material prevalent in medical education has concerned educators. The memorising and reproduction of factual data should not be allowed to interfere with the primary need for fostering the critical study of principles and the development of independent thought, (Tomorrow's Doctor, 1993).

These concerns coupled with a changing society have advanced the need to re-evaluate higher education. The way in which a topic is taught determines the usability of the newly acquired information. Prior knowledge and the structure in

which it is available in long-term memory will determine what is understood in applying the knowledge to a new situation.

What qualities do we want to see in our graduates, (Graduate Standards Programme, 1996)?

knowledge of the discipline (content)

ability to solve problems

ability to work collaboratively

ability to learn for themselves

ability to think like a doctor, lawyer, engineer,...

This list of desirable attributes could have been written a hundred years ago. But the ever increasing speed of change in today's society has encouraged a re-examination of higher education. Advancing technology has increased the acquisition and dissemination of knowledge to a point that renders much of factual data gathered during school years obsolete by graduation. A changing world has increased the need for professionals to continue to read and learn throughout their career.

Higher education in these professional programs must be:

- ◆ a curricular organisation around problems rather than disciplines; an integrated curriculum rather than one separated into basic science and clinical science components with an inherent emphasis on cognitive skills.
- ◆ student centred instruction promoting active learning and independent study; a program that enhances functional knowledge, the development of skills and the motivation required for continued learning and the development of skills of self-assessment.
- ◆ a program that prepares future professionals to adapt to change and to reason critically enabling a holistic approach to medicine.

One solution that satisfies all these requirements is Problem-Based Learning.



### 3.1 Problem-Based Learning

The philosophy behind Problem-Based Learning (PBL) can be traced back to John Dewey and the constructivist epistemology. It began in the 1950's at Case Western University and emerged some ten years later in Canada at McMaster University where it was and continues to be utilised in the Medical School (Savery, 1994).

It is my opinion that PBL is at the forefront of educational reform and, its acceptance as an educational approach with wide application represents a major change in thinking about educational processes and their relationship to the wider community. It is couched in the language of cognitive psychology and learning theory and its underlying value for lifelong learning has helped to push it into reality. However, the use of the term Problem-Based Learning is considered negative by some and misleading by many. Serving to deepen the confusion, a number of synonyms such as; Integrated Learning, Pathway Models, Project-Based Learning, Case-Based Learning, Evidence-Based Learning and Situation-Based Learning have been presented (Walton & Matthews, 1989). All are essentially similar to PBL; yet anyone affiliated with one of these would quickly point out the differences that make their program unique and the list continues to grow.

I assert that professional pride manifests a reluctance to admit the need for educational reform in many disciplines especially in the areas of law, engineering, architecture and the health sciences. After graduation these professionals look back on highly selective admission requirements, long tedious hours of study, and difficult assessments. With good reason they are prominent members of society and take pride in their accomplishments. The mere hint that their education could have been better is met with strong indignation. But these are the professional programs where PBL is at its best.

In too many cases, those who try to introduce these new programs must do so under the guise of more traditional approaches. Others who have had the change thrust on them are using the jargon of PBL to redefine existing programs. To deepen the maze further, there are those who adopted PBL early in its existence and now feel that the exclusivity of their program is being threatened. They attempt to remain special by narrowing the definition of PBL. Today when confronted with one of these

increasingly diverse programs all we can say with assurance is that the primary transmission of information to the student is not the traditional lecture.

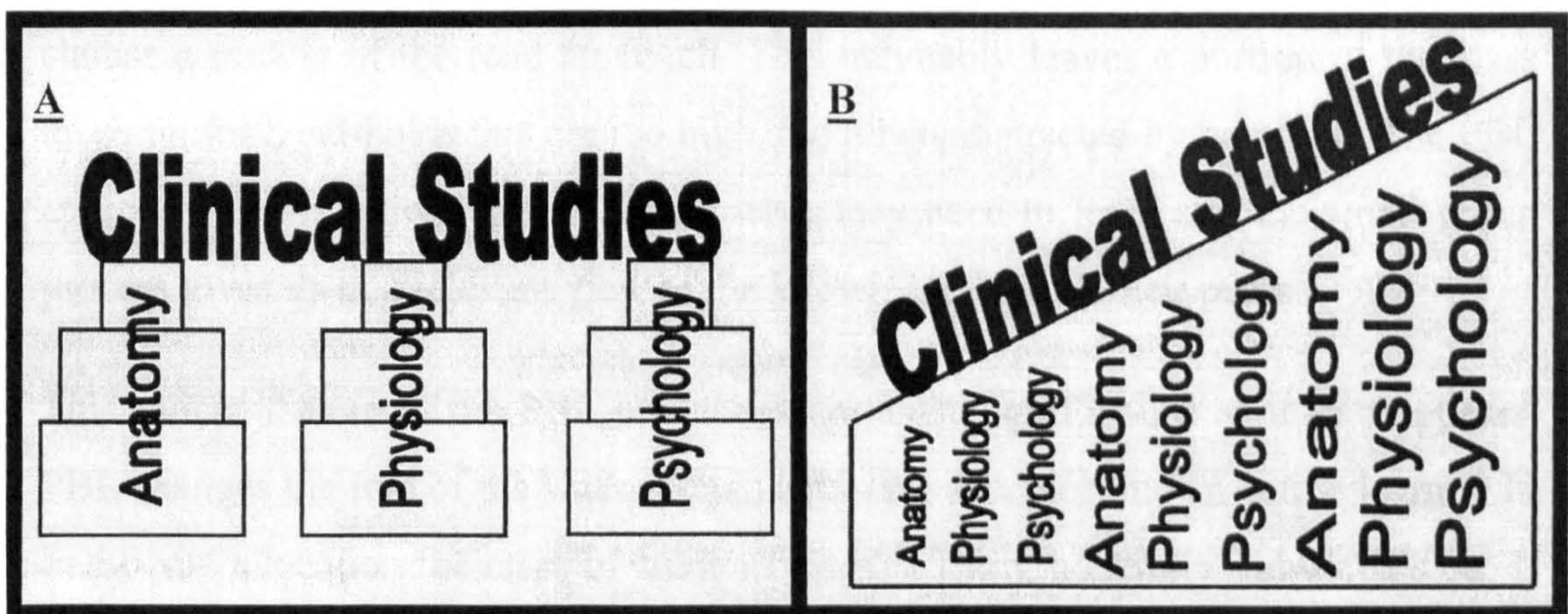
The number of universities opting for a PBL approach is expanding. Currently there are more than a hundred such programmes in undergraduate medical education. Postgraduate Medical Schools have been a bit slower to endorse the programme, but there are some notable exceptions. Harvard Medical School was one of the first schools outside of Canada to embrace the PBL philosophy and subsequently a number of other professional programs at Harvard have followed suit (Abrahamsom, 1987). Barrows at Southern Illinois University has championed the cause, conducting research, holding workshops, and publishing papers for more than twenty years. Barrows (1986) describes the basic process -

- ◆ The problem is encountered first in the learning process, before preparation or formal study has occurred.
- ◆ The problem is presented to the students in the same way it would present itself in reality.
- ◆ Students work through the problem in a manner, which permits their ability to reason and apply knowledge to be challenged and evaluated in a way appropriate to the current level of learning.
- ◆ Needed areas of learning are identified as the problem is explored and used as a guide to individualised study.
- ◆ The skills and knowledge acquired by this study are applied back to the problem, to evaluate the effectiveness of learning and to reinforce learning.
- ◆ The learning that has occurred in working with the problem and in individualised study is summarised and integrated into the students' existing knowledge and skills.

Traditional education produces isolated content specific chunks of knowledge, Fig.3.1. As students advance through the pre-clinical curriculum each department strives to increase the depth of knowledge in their particular discipline. With each layer these ever growing collections of facts become increasingly isolated. Only real



life, professional experience, begins to integrate these isolated databases. It is understood and accepted by many students in traditional programs that university is where certification is obtained while learning their craft is accomplished on the job. The PBL process, in itself, advocates an integrated form of education. This integration doesn't have to be spread across the entire range of possibilities but be applicable in solving real-life problems. This tie to reality not only enhances the interest of the students but offers more opportunities for cognitive processing, both academic and social.



**Figure 3.1 Traditional Curriculum versus Problem-Based Curriculum**

**A** illustrates the lack of integration that is common in traditional medical education. Pre-clinical preparation takes place in separate disciplines and as the depth of study increases in each discipline so does its isolation.

**B** illustrates the integration of disciplines that is the focus of Problem-Based Learning. In the PBL format the depth of study increases uniformly providing more applicable and better support for the clinical training to follow.

Professional competence is fostered through an inquisitive style of learning, not the passive collection of facts. Intrinsic motivation is strengthened by the integration of basic science concepts into clinical problems and enhances self-directed learning.

Schmidt (1980) described the learning process and indicated that the quality of education suffers if any of the following activities are not present. Prior knowledge has to be activated, information has to be presented in the frame of a real life problem and the students have to elaborate on their knowledge. All of these factors improve the retention of knowledge. Starting with the activation of prior knowledge, learners construct explanatory models, which enhance comprehension and the processing of new information. New information is appropriately attached to prior knowledge and



then elaborated. The presentation of real life problems constructs rich cognitive networks in the minds of the learners. In this way knowledge is contextually situated and the cues for recall are within the knowledge structure and offer multiple points of access. This provides an apt description of the core of the PBL process.

The first goal of PBL is the activation of prior knowledge since this is necessary for learning to take place. Instructional methods vary in their ability to unearth the relevant prior knowledge. In traditional education the class syllabus is decided by administrators far removed from the classroom. Enlightened teachers who assess the current knowledge base before beginning instruction are somewhat compelled to choose a middle of the road approach. This inevitably leaves a portion of the class reaching for hand-holds that are too high and others distracted by boredom. The PBL approach allows individuals to decide what they need to learn and the small group process gives them a relevant view of the knowledge base of their peers.

This salient feature of the PBL process is not as straightforward as it first appears. PBL changes the role of the student from a passive acceptor into an active learner. In traditional education the class of students doesn't learn, hopefully individuals do. It should not be forgotten that in PBL the small group doesn't learn. PBL is an educational process that is more closely aligned to the individual student than the traditional process. But learning is an intimately personal process that can only be accomplished by an individual. The ability to choose what they 'need to know' provides relevance and enhances the motivation of the students. The initial discussion of the scenario provides a group consensus of the appropriate starting point for further learning. This starting point is the group's, not the individual's, but the discussion allows individuals to compare their personal knowledge base to other group members. In this way the small group process provides constant feedback to the students about how they are doing compared to their peers. If individuals are consistently struggling to keep pace, they need to study more. If they are lacking in a certain area they can do some additional reading on the topic. Average students will be pleasantly surprised by what they know as often as they are unpleasantly surprised. Students can counter the long periods between formal assessment with accurate relevant feedback.



Once the appropriate prior knowledge is activated, by application to the problem in hand, it should be elaborated. This elaboration begins during the initial discussion. It is unlikely that the students have seen this particular problem before so the act of arranging their current knowledge base in this way becomes an elaboration in itself. The elaboration of prior knowledge is not just the addition of data. The application of knowledge to novel situations creates unique cognitive structures. Each of these creations has two potential outcomes. One possibility is that the arrangement provides feedback, positive or negative. This feedback forges a link that will alter either the structure or application of knowledge in future use. The alternative possibility is that no discernible feedback is received. This does not imply that the attempt was a waste of time, sometimes no answer is an answer. It is also possible that there was implicit feedback at the subconscious level that would affect subsequent application. Even if no gain is made, explicitly or implicitly, the process has some benefit. It provides the students with practice in mobilising their database. It could be argued that the difference between an average and an excellent practitioner is generally not a difference in the amount of knowledge, but a difference in the flexibility and application of knowledge. As the discussion continues the real and imagined insights of other students take tentative places within the expanding cognitive networks of all. As questions are formulated for additional study, the mind of the individual is prepared for further elaboration.

The initial presentation in the form of a problem creates a link between the context of the particular knowledge and the retrieval cues which will be useful in the future. There are a number of examples illustrating this point. After travelling many hours on a plane and then renting a car and driving a few more hours to your holiday destination, it would not be unusual to pass a co-worker or even a family member in the lobby of the hotel without recognising them. Gooden (1975) provides another example of this when he reports that divers who learned word lists underwater were better able to recall the lists underwater. It is important not to accept blindly this attribute of the PBL process. If the statement of contextually situating knowledge is taken to the extreme the result is an automated recall of facts triggered by recognising having seen the exact question before. This is actually a characteristic of traditional education that we are trying to avoid. It is the nature of the PBL process that when a student recalls a particular scenario they will recall a surprising amount

of surplus seemingly irrelevant information, such as the patient's name, hair colour, clothes, family,...

Anyone who has acted as a Facilitator for these small groups can recall a similar exchange.

Student 1,

*This is just like that case we had before, you remember, with Mrs. Green.*

Student 2,

*Oh yea, her daughter had that eating disorder. What was that blood test they did? I can see the table, you know on the handout...*

As educators we find this circuitous path of reasoning mildly amusing but ultimately satisfying because a correct answer was found. This backward reasoning process is a consequence of presenting scenarios to the students but it is not their intended manifestation. When a student confronts one of these multifaceted, real life scenarios they wrap their prior knowledge around it in an attempt to understand it. This mobilisation of prior knowledge aligns both the relevant and irrelevant bits. If a connection is made through truly irrelevant facts it is hoped that by pulling the two databases closer together through any connection, a more logical, more useful link will be formed. The goal is to form a logical link, shortcut, between presenting symptoms and diagnosis. This is accomplished through the repeated activation and mobilisation of prior knowledge. Each effort adds strength and suppleness to the expanding database. This process mimics that of a new professional practising his craft, gaining experience through repeated application. A student can develop these same mental gymnastic skills by addressing a number of scenarios. The student should not just address scenarios where further study and knowledge is necessary. In fact, for every scenario that expands the database, the student should address several that just manipulate the newly acquired information. This will facilitate the transfer of knowledge and concepts learned in one context to application in another. Every time prior knowledge is applied to a new situation it broadens the range of stimuli to which it will respond. This broadening likewise reduces the isolation of situated knowledge and narrows the jump required to apply it to very different presentations.



In this way students can actually gain experience of the kind that has been reserved for those in professional practice.

PBL gained acceptance by tying learning to what is generally accepted as relevant to professional practice. But relevance is an ever-changing paradigm. It is a great strength of the PBL process that 'scenarios' can be updated as the profession demands with little alteration to the rest of the process.

## 3.2 PBL at Glasgow

As has been the case around the world, part of the impetus for change at Glasgow grew out of concerns voiced by various august bodies of professionals. Included in the list of those calling for change were the American Medical Association (AMA), the World Health Organisation (WHO), and the General Medical Council (GMC). In December 1993 the Education Committee of the GMC published their Recommendations on Undergraduate Medical Education (Tomorrow's Doctor, 1993). In section 33 under the subheading 'Learning systems' they state

'Medical schools are well aware of the merits of the learner-centred and problem-oriented approaches and are striving towards their adoption, moves which are strongly encouraged. Most are reducing their reliance on the didactic lecture format and are promoting small group learning wherever possible.'

The publication concludes with Principal Recommendations among which, in Annex A, are Attributes of the Independent Practitioner. Some of the attributes listed are:

The ability to solve clinical and other problems in medical practice, which involve or require:

(a) an intellectual and temperamental ability to change, to face the unfamiliar and to adapt to change;

(b) a capacity for individual, self directed learning; and

(c) reasoning and judgement in the application of knowledge to the analysis and interpretation of data, in defining the nature of a problem, and in planning and implementing a strategy to resolve it.

The language used and the goals proffered by the General Medical Council are close to those of Problem-Based Learning.

The PBL programme at Glasgow began in 1996 and offers a system-based, fully integrated curriculum which combines the traditionally separate disciplines of anatomy, physiology, microbiology, pharmacology, behavioural science and sociology. This curricular integration is a fundamental part of problem-based learning.

The scenarios (problems) presented to the students describe real-life situations that could be encountered during postgraduate practice. A series of changing encounters with 'patients' within a time frame provides relevance. The scenarios are seen through the eyes of a new doctor who often seeks advice from senior staff.

The Medical Education Unit (MEU) at Glasgow publishes a number of handouts explaining the philosophy and describing the process of their PBL program. One such handout highlights the 'Glasgow Steps' which are used by students and Facilitators alike as a template for the small group process.

## The Glasgow Steps

1. Do you understand the scenario?

Are there any words you don't understand?

2. What are the main issues in the scenario?

3. "The Brainstorm"

Generate explanations of the main issues based on your existing knowledge.

4. Decide on the exact questions on which you need to work.

5. Plan your use of resources.

*The enquiry phase\**

6. Pool and test the new knowledge.

Reflect on the adequacy of your answers  
and the appropriateness of your questions.

7. Reflect on the group process.



\* The enquiry phase of the process is independent study for the students. The students have two days to work on the questions generated in step 4. Whenever possible the topic of labs and occasional lectures coincide with the learning objectives of the current scenario.

### 3.2.1 Small Group (Process)

The PBL group, consisting of eight or nine students and a Facilitator, meet for two hours twice a week. Each meeting is led by a student chairperson and consists of answering the questions generated in the previous session then beginning a new scenario. The Facilitator monitors the depth and breadth of the feedback session (step 6) and probes accuracy and understanding to assure that learning objectives are reached. As a new scenario unfolds, a student scribe records the discussion and the exact questions to be answered.

The roles of chairperson and scribe are taken on a rotating basis. This rotation will vary from group to group, one group choosing to establish a roster on day-one and then proceeding through it from session to session, other groups prefer to volunteer for the role at the time of need, being sure that all members take a turn. The chairperson runs the session, seeing that all of the members are included and keeping track of the time so that a particular question or discussion doesn't monopolise the meeting at the expense of other areas.

When a new problem is undertaken one of the students reads the scenario aloud (step 1). As the scenario develops the scribe uses a white-board at the front of the room to record the main issues (step 2) selected by the group. In the usual convention these are listed down the left side of the board. As the 'brainstorm' (step 3) continues, the variable mixture of truth and knowledge, the individual perceptions of the problem and its context, conspire to multiply exponentially the number of potential starting points and outcomes. Framing of the problem therefore requires framing of the context. As a group, the students discuss the scenario and collectively probe their understanding. During the discussion the scribe uses a loose, open form of recording the final appearance of which mimics the structure of a mind map. This recording is primarily an inventory, where exact links and associations are only approximated. The particular style and accuracy is a reflection of the scribe's understanding and recording abilities rather than a group interpretation. When all of the issues have

been discussed, exhausting the prior knowledge of the students, questions (step 4) are generated for further study. The scribe records these questions exactly as agreed upon by the group.

These roles taken on by the students serve two purposes. First, they are necessary components of the group process, providing an organising function for the small group dynamic, assuring that the desired goals are achieved in a timely fashion. The roles also foster a sense of responsibility and leadership. Second, even though the chairperson and scribe remain part of the group, asking questions and discussing issues, their additional obligations provide some separation and they view the group from without as well as within. This altered perspective can be very enlightening regarding the group dynamic, illustrating how some members dominate, others withdraw, and what factors break the concentration and rhythm of the group process.

### 3.2.2 The Facilitator (Tutor)

The teacher in these small groups is known as a Facilitator or tutor. The tutors do not lecture or impart knowledge; they facilitate learning. For most if not all educators this is an unusual position. Succinctly the job of a tutor is to model, coach, and fade away.

What should be modelled for the students is not the correct answer. The tutor should model the correct questions.

What is going on here?

What does that mean?

Where have I seen this before?

The tutor should act as a metacognitive guide for the students, thinking aloud the questions the students should ask themselves. Since we are all individuals and our areas of expertise will vary, a precise sequence of questions is not the goal. The desired endpoint is when the students automatically begin a thoughtful, reflective exploration when confronting a new situation or problem.

As the group begins to tackle the problem on its own, the role of the tutor changes from modelling the desired process to coaching from the sidelines. The tutor must



refrain from directly supplying the correct answer and should avoid expressing an opinion as to the correctness or appropriateness of a student's response. Viewed from the outside, the expert tutor is much like the expert horseman. The horse starts, stops, changes gait, and performs intricate manoeuvres; the horseman appears to do nothing. Tutors must challenge unsubstantiated claims, right or wrong, they must probe understanding, they must ensure that all group members are involved in the process. The tutor must do all of these things without monopolising the conversation or breaking the momentum of the group. This is a delicate skill which some teachers and experts find exceedingly difficult to acquire. For those still entrenched in a didactic style of teacher-student interaction the temptation to lead the discussion is hard to resist. Once a tutor takes over, the inevitable outcome is a lecture ending with a satisfied smile on the face of the tutor; the behaviourist is now satisfied that he has taught the students what they need to know. This brings up an interesting question.

Should the tutor be an expert in the particular discipline that is the subject of the scenario? There has been a significant amount of research on this topic; no consensus has been reached.

Some studies have advocated the expert, rationalising that they can quickly and accurately step in and move the group past a sticking point (Mayo, *et al.*, 1993). This may be logical, but the tutor should not provide answers for a very good reason. During the brainstorming session the students should activate and mobilise their prior knowledge generating questions that need answers. This prepares their cognitive network for the link to come. Consciously and subconsciously (see Chapter 1), the students manipulate various pieces of their database searching for a proper fit, each attempt supplying feedback and increasing understanding. If the answer is supplied to the students prior to this internal search, it has a reduced impact. Even if the correct answer is recalled, the students lose the explicit and implicit feedback, which is given during failed attempts.

Other studies, e.g. (Silver & Wilkerson, 1991) prefer the non-expert, though not exactly for the reasons that I just mentioned. Their study was conducted over 11 weeks with first year medical students at Harvard Medical School. They found that tutors who considered themselves experts in the discussed topic, spoke longer and more often. They provided significantly more direct answers and were more likely to

select the topics for discussion. Tutor to student interactions dominated the group rather than the desired student to student discussion. The 'expert tutor', contrasted to the subject expert, provides gentle guidance in the correct process, not correct answers.

The ideal choice would be the subject expert who is also an expert tutor. So what are the characteristics of an expert tutor? Expertise in any area has common attributes, understanding, desire, and practice. Students were questioned regarding desirable tutor traits (Feletti, *et al.*, 1982) The students respected subject expertise and they appreciated expert tutors, but they preferred tutors they liked (subjective analysis). What they liked was not just a pleasant personality or 'one of the guys'. They liked a tutor who seemed genuinely interested in them. Someone in whom they were confident; who would not allow them to leave a session without having covered all of the objectives. Someone who reminded them of upcoming labs and lectures that could provide insight into the topic of discussion. Someone who was aware when problems in understanding arose and found answers; even if they provided none of the answers themselves.

### 3.3 Problem-Based Learning, Past

My first encounter with PBL was twenty years ago. I was working in a large teaching hospital where students and residents during their surgical training and rotation were involved in a program called Problem-Based Learning. This title, Problem-Based Learning had become a buzzword in medical education. The surgical staff had found some similarities between the description of PBL and their own programme, they both started with a problem. They decided to apply the title, PBL, to their existing programme. The rest of medical education in this programme was in the traditional format, which lacked the integration of subject matter from different medical disciplines. This was a time when medical education was at its elitist zenith, only the brightest need apply. Acceptance into Medical School was reserved for those with the highest test scores and the line between success and failure of entry was often a tenth of a point. In retrospect this was the type of programme that has created apprehension in the minds of administrators who subsequently considered the adoption of Problem-Based Learning. What they were seeing was not problem-based learning, but problem solving. The students were confronted with a predefined



surgical problem and were given only one tool with which to solve it, 'the knife'. I watched and listened as these students grappled with their assigned cases. Their minds raced to and fro as they used both inductive and deductive reasoning to eliminate the offending symptoms. They considered severing the intricate loops of both positive and negative feedback mechanisms at various stages as they struggled to reach their goal. The patients were not people but problems to be solved with their new found tool.

This programme, unfortunately called Problem-Based Learning, no longer exists as described, but it was not an isolated case. It was an accurate example of medical education at the time and illustrates a number of problems that eventually led to a world-wide call for reform in medical education. The first problem to be addressed was the selection criteria used to evaluate new applicants. Some years ago a number of schools expanded their selection criteria to include a number of non-academic factors, a change designed to admit more rounded individuals into Medical School. The rigors of medical training demanded that academic achievement remained central to the selection process but it was no longer the only factor.

The next problem to be addressed was the tendency to treat the symptoms rather than the cause. To a large extent this was a consequence of the state of the 'art' at the time, and was never the overt desire of the profession. The symptoms are what brought the patient to our attention because they are what we could see, touch, and measure. We had to make an educated guess at the underlying pathology. As the body of medical knowledge grew our guesses got better. This constantly improving medical knowledge coupled with an effort to treat the whole person rather than just the part that appears broken has improved medical care around the world. These changes have altered both the practice of medicine and the education of its practitioners.

As previously mentioned this programme no longer uses the PBL title. This misnaming has been damaging on a number of fronts. Dropping the PBL title was done in an effort to distance the programme from 'problem solving'. Ironically the PBL title had been erroneously applied to an existing programme and was now being dropped as part of world-wide reform in medical education. The difference in problem solving and problem-based learning is straightforward. Problem solving is

the selection and arrangement of data culminating in the correct solution. Problem-Based Learning is the use of a real life problem as the stimulus for the acquisition of data. The programme mentioned above was problem solving, but that in itself is not inappropriate. For the medical practitioner diagnosis is the ultimate problem to solve. What was inappropriate was offering only one method of solving the problem. This restricted both the acquisition of data and its subsequent application. The dilemma was created by the lack of integration of the medical disciplines. The ensuing holistic approach to medicine addresses the patient as an individual and as a member of society. This change actually moved traditional medical education more in line with the philosophy of PBL. It is unfortunate that this theoretical step forward in medical education was a step backward for the practical application of Problem-Based Learning.

### **3.4 Problem-Based Learning, Future**

During a recent visit to the States I visited the newly formed College of Social Work within the University of Kentucky. They were in the process of converting their traditional classes, as a part of the Psychology Department, to a Problem-Based approach in the new College.

The University had seen the development of a new Department as an opportunity to introduce Problem-Based Learning into their undergraduate curriculum. As previously mentioned, the language of PBL is appealing to professionals and educators alike. Unfortunately some further impetus is usually required to break with tradition and to address the very real staffing changes required to implement PBL. They had studied a number of papers and attended conferences and workshops in Washington D.C on PBL. The Dean of the College commented that PBL had had a significant impact on medical education, turning out doctors who were 'more human, more socially aware'. 'I don't know if it will have much impact on our students. That's what we teach our students now.' I commented that PBL was likely to mean that their new graduates would be less human, less socially aware. This statement was neither well received nor understood.

I explained.



In traditional medical education students learn biochemistry in Biochemistry class and the science becomes far removed from the box that contains it, the human element is lost. Problem-Based Learning begins with a real life scenario that would be confronted in professional practice. This means that students begin with a person and in most cases they know their name, age, physical appearance and immediate family. While none of these humanising agents may be the particular learning objectives which administrators associate with the scenario, they provide an anchor that the underlying science is tied to. The students' academic exploration both begins and ends with a person.

A student pursuing a career in Social Work would traditionally obtain a degree centred around the disciplines of Psychology and Sociology. This meant that the new graduate was well versed in the human element as an individual and as a part of society. But what type of problems might the professional social worker encounter? In their professional role they work for and co-ordinate a number of government agencies. They dispense aid either financial or psychological, based on marital status, number of dependants, and income. They match responses on a questionnaire to a plethora of tables and charts. In many cases their decisions are made from a cubicle far removed from the individuals they are evaluating. A scenario stemming from the real life problems faced by professional Social Workers would incorporate the dehumanising element of demographics into their undergraduate education. So the reality of their profession would actually produce graduates who hold the human element at arms length. Through the careful selection of problems and the influence of Facilitators this dehumanising may be reduced. But if the philosophy of PBL is upheld it cannot be eliminated. That is a political decision not an educational one.



*Until a few years ago educators believed that once you had acquired expertise it was merely a matter of transmitting that information (knowledge) to the students. With the realisation of individual differences, different ways of knowing, researchers have found that there is not a single method of transmitting information that is appropriate for all learners. This should have been a dramatic change in education, but emphasis*

*remained on what the teacher did. Learners were still considered sponges that differed only in their ability to absorb information presented in various ways.*

*The call for reform in higher education has grown louder in the last few decades. The response in a growing number of pre-professional programs, medical education in particular, has been Problem-Based Learning. In PBL, students in small groups are presented a real life, ill-structured, problem. The task of a group of students is to explain the presented phenomena in terms of underlying process. Explanations take the form of physical, biological or psychosocial mechanisms that may be underlying the phenomena concerned.*

*The problem is presented before any formal study is undertaken and serves as the organising centre and context for learning. The initial presentation of the problem activates the student's prior knowledge and prepares their cognitive database for the appropriate addition of new information. This process integrates the traditionally separate science disciplines that comprise pre-clinical medical education. Teachers assume the role of cognitive and metacognitive coaches rather than knowledge holders and disseminators. The student shifts from the passive acceptor promoted by traditional education to a decision maker, a meaning constructor, an active learner.*

*PBL provides relevance to learning by presenting real life problems. Few situations in real life, personal or professional, present themselves with all information readily apparent. Some of the needed information is obtained by further questioning and probing. Knowing where to probe and what to ask requires thought and deliberation. This newly gathered information is combined with and propelled by knowledge in the memory of the problem solver. Information recalled from memory ranges from automatic associations generated from experience to purposeful manipulation of the personal database. Even after careful inquiry and analysis the problem may not appear totally understandable. This is the nature of the ill-structured real life problem.*

*Traditional education has viewed learning and problem solving as different and mutually exclusive. But, there is no better way to store knowledge than to use it to accomplish some task beyond the stored fact. This realisation has come to life via*



*work on information processing and learning theory, highlighting effective and efficient learning.*

*Barrows (1988) stated that the novice must acquire, through practise, well developed cognitive skills to monitor, to view critically and to direct the development of their reasoning skills as they work with life's ill-structured problems; to appraise the adequacy of their knowledge and to direct their own continued learning.*

*To become independent thinkers and be able to learn on their own for the rest of their lives, students must not be put into the passive learning situations fostered by traditional education. Students should be actively involved in deciding what needs to be learned. In PBL, students experience the intellectual satisfaction of following clues rather than just being told what to do. Previously unrelated concepts become connected in memory, and newly produced insights change the cognitive structure.*

*PBL is the structuring of knowledge for use in clinical contexts; the development of an effective clinical reasoning process; the development of effective self-directed learning skills and increased motivation for learning.*

*The conscientious student, reflecting on a problem at the end of the day is developing the skill of a 'reflective practitioner'.*

## Chapter Four

### *The Proposal*

At every turn we compare our present to our past; we learn, we live by association. Traditional education holds this natural process at arm's length. Students seated in the classroom are asked to record passively and assimilate data, presented at a pace and in an order not their own; data the relevance of which stems from the need for a passing grade not the desire to understand. Students memorise linear data strings the tail of which extends far beyond the horizon. Data strings are selected by a keyword at the head, a keyword matched to time of day, to a particular class (Biology, Chemistry,...), to a particular assessment. The favoured data string may be chosen without regard to its content. At best these data strings are recalled, not applied. Even the most successful student will find the transfer of information, organised in such a manner, impossible. The students may understand the words but not the implications of this information. Understanding requires some insight into the practical application of information. Assimilation of information is accomplished by activating relevant prior knowledge and then appropriately attaching the new information. It is the structure of knowledge in long term memory that determines what students can do with it.



Concept mapping can be a powerful aid to memory, understanding and concept development. Concepts are organising ideas that help us make sense of the world, and learning is developed through organising information and ideas into patterns and frameworks of understanding. Mapping helps students to represent thinking in visual form, to depict relationships between facts and concepts, and relate new information to prior knowledge. Mapping can take many forms and be used to support a wide range of contexts for learning and may provide a focus for group discussion and be a means to facilitate small-group learning.

PBL and concept mapping encourage students to be actively engaged in thinking, and to elaborate and build on their ideas. The students not only receive information but rethink it, interpret it and relate it to their schemas of understanding. Both processes, PBL and concept mapping allow for the unique and idiosyncratic nature of each individual's system or structure of meanings while recognising the necessarily shared nature of human understanding. Concept mapping can help information flow to, from and among students and facilitators. Most important, students learn a procedure for investigating, visualising and organising information. The theoretical constructs of learning, concept mapping and PBL are discussed in Table 4.1.

Concept mapping is not just another problem solving strategy. It is an overt expression of the natural learning process. The precise procedure should not be the focus of attention; individuals should develop their own style. Concept mapping allows the student to have an intimate conversation with the situation. By making the process a personal learning tool, the difficulty in transferring learning to new domains is reduced.

The development of expertise has been seen as the consequence of domain specific rehearsal and over-learning. PBL, and concept maps, seek to induce expertise through elaboration and the creation of links between episodic memory and declarative (semantic) knowledge.

	<b>Concept Mapping</b>	<b>Problem-Based Learning</b>
Activate Prior Knowledge	Concept maps offer a method of visualising prior knowledge in the form of broad concepts and attaching the specifics of new information.	PBL activates prior knowledge by its application during the brainstorming session. This process also highlights gaps in knowledge.
Information Supplied in the Frame of a Real Life Problem	My method of concept mapping enhances the natural learning processes. The use of a real life problem to begin the process promotes the integration of the academic and social databases.	PBL uses real life scenarios for two reasons; to tie new information to the likely cues for recall (encoding specificity), and to increase student interest by showing the relevance of new information to their chosen profession.
Elaborate on Prior Knowledge	Concept maps provide a structure on which new information may be assembled. The visualisation of this process allows its thoughtful integration into the students expanding database.	The focus of PBL is the elaboration of prior knowledge. The students begin their process with what they already know. They then generate questions based on what they need to know to adequately understand the scenario presented.

**Table 4.1 Concept Maps and Problem-Based Learning**

Problem-based Learning and concept maps work in concert, promoting the higher order cognitive abilities of analysis, synthesis, and evaluation.

**The following section, 4.1, is the exact proposal submitted to the Glasgow Medical School two years ago. [Clarification will be provided in brackets]**

## 4.1 The Proposal

The objective of any enhancement to medical school curriculum must emphasise the development of those abilities, skills, and attitudes desired in the graduate. It is, or should be, the goal of physicians to continue learning throughout their professional lives and therefore to be contemporary, in both medical knowledge and practice. **It is proposed** that a students' familiarity with retrieval maps (their own) should provide



an appropriate structure on which to hang new information. The incorporation of new material into this existing structure should allow it to quickly become a useful component of the physician's diagnostic tools. Simply stated, the task of self-education has become essential to the practice of medicine.

There are problems in assessment with PBL, due to the group format. The ability of one student to reason, recall, and apply relevant knowledge is not observed, but only inferred. **[The PBL process is described in Chapter Three. PBL by design has fewer assessments than traditional education. The students meet in small groups to plan their learning goals and to discuss new information subsequently gathered. A Facilitator (tutor) meets with each small group of students and must infer individual understanding from the group discussion.]** It is proposed that a retrieval concept map is an individual effort and consequently allows insight into the particular abilities of the individual. This insight may be invaluable in planning further learning goals, but its usefulness will be destroyed, both to the learner and the educator, if it is used as a direct form of assessment.

“Process and content are like the blades of scissors that must work together to cut through the problem.” I don't recall the source of this quote, nor am I convinced that I like it. But, it does underscore the necessity of a harmonious interaction of both process and content to achieve the desired goal. The clinical reasoning process is of no value without an extensive knowledge base on which to operate. **It is proposed** that a retrieval concept map will provide a structure for this growing knowledge base that will facilitate the reasoning process to come.

As students struggle to come to grips with PBL, their confidence will become shaken. The learning is no longer teacher centred. They can no longer examine a syllabus and get a thumbnail sketch of the material to be covered and the concepts they are expected to understand. **It is proposed** that the retrieval mapping will allow students to put pen to paper in a meaningful manner. One goal of this research is to instil the students with metacognition. At first, a reflection of how their mind organises material will seem an assignment of its own, but as the process becomes more practised it becomes a valuable tool. Medical students, in their haste, may quickly grow to think it slow and cumbersome. **It is proposed** that by slowing the

ever quickening responses of these over-eager students that retrieval mapping is its most useful. Alternative pathways cannot be seen if their branching points are passed in the blink of an eye.

We all take short cuts with repetitive problems, no longer thinking through all the possibilities. These shortcuts can lead to error if the encountered problem had unusual features that were not detected. The traditional study and retrieval methods are manifest by understanding the question and then directly retrieving the answer. It is seen as a one step process, very much like the retrieval of 16 when one sees 4 x 4. While this process is acceptable for some basic knowledge and to a lesser extent that this particular one step response base will grow with a learners sophistication, it is not desirable for all information to be retrieved in such a manner. In fact it could be quite dangerous for new internists to form conclusions in this way.

In PBL, information is gathered horizontally. **[In the PBL process students address a real life problem of a kind that they would confront in professional practice. In an effort to understand the problem students gather all pertinent information and so the traditionally separate disciplines of medical education must be integrated.]** It is imperative, especially in the first couple of years, that no hierarchy be applied to the individual concepts. **It is proposed** that retrieval mapping is a way of expressing concepts without distinguishing a specific priority.

## PREPARATION

Students will be provided with a handout containing a brief summary on study planning, linked learning, and concept mapping.

A lecture presentation will be made during week (6?). **[In the Medical School the academic year is divided into Blocks lasting five or six weeks, my first contact with the students (lecture) was planned between Block 1 and 2.]** I can cover the basics in 15 minutes and would prefer to give out the material at that time. The appropriate steps for concept mapping will be explained and illustrated. The idea of the mapping will follow the traditional guidelines of planning an investigation. The particular form I want the students to use is new and is designed to



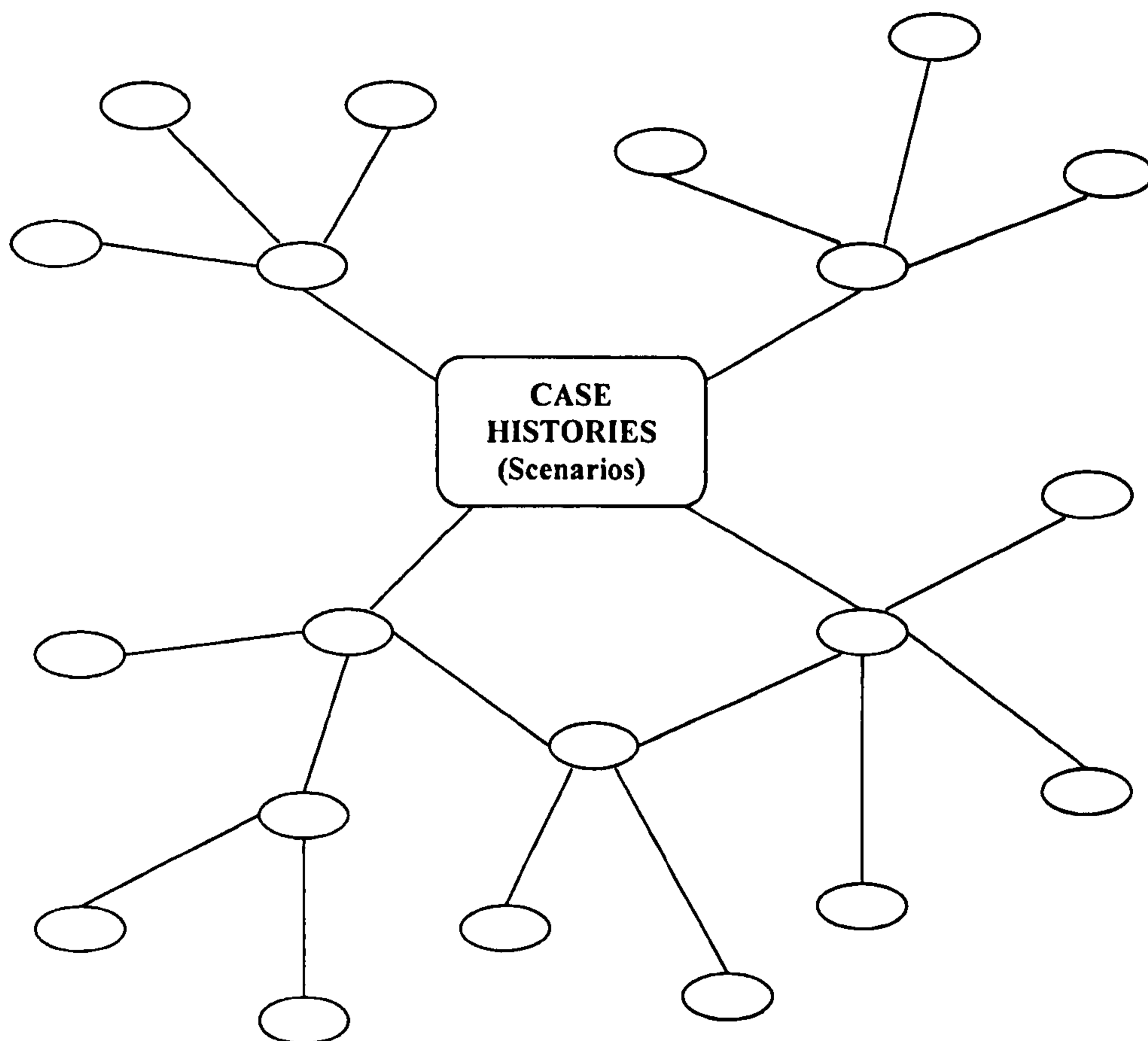
enhance the retrieval and/or organisation of studied material. It is a natural tendency for information to be both chunked and linked in the learner's cognitive network. By making the students aware of these facts, their initial planning map will be somewhat more organised whether it is externally visualised, or only internal.

There has been substantial work done on concept mapping as a planning aid and it has been shown to improve understanding significantly and therefore improve assessment performance. The theory underlying the usefulness of concept mapping is very similar and runs parallel to that of PBL, therefore the focus of this work is on retrieving the information rather than how it is laid down. It is arguably a mirror image of the planning map. It should be noted that this particular research will not ascertain that fact. It is almost without question that one's concept map changes as the breadth and depth of knowledge increases. This is not just adding to the existing map, but the altering of the layout by increased chunking and layering.

At the appropriate time prior to the beginning of block 3 or 4 (the trial period) **[Data was to be collected from 10 scenarios beginning in mid January during Block 3.]** another 15 minutes will be needed. I will remind the students of the process and show them how to use the three part forms. An envelope containing the forms will be left with the facilitator each week and the previous envelope will be picked up. The students can take a new form from the envelope and deposit their completed ones at the beginning of each group meeting. In addition to the forms for the students, I will supply a form for the facilitators. This is will be a labelled 'two-part form'. I would like the facilitators to record the main issues and the questions posed. The facilitators record this information already. After they use the provided form; tear off the bottom sheet and put it in the envelope, the top copy of the form can be kept by the facilitators for their records.

An externalised concept map may imply that the retrieval of some knowledge follows a rather circuitous path. This is a consequence of the externalisation. I do not presume to understand the intricacies of the brains hard wiring, only to caution against imposing the picture created by the students too literally. It is the contention of this research that the externalisation of the route of retrieval of information will enhance the learner's awareness of possible alternatives.

It is neither the goal, nor desirable, for this process to explore all alternatives. The retrieval map should provide appropriate nodes of hesitation where the student is exposed to other branches of thought. As a learner proceeds from a node they should be either positively reinforced or continuing cautiously, depending on their comfort with the chosen line. The retrieval of information in this manner should greatly enhance a learner's problem solving ability. As learners become more familiar with their own cognitive network their ability to assimilate the knowledge in novel ways is improved. This of course, is the basis of problem based learning, to enhance the usefulness of learned information.



**Figure 4.1 A cognitive network**

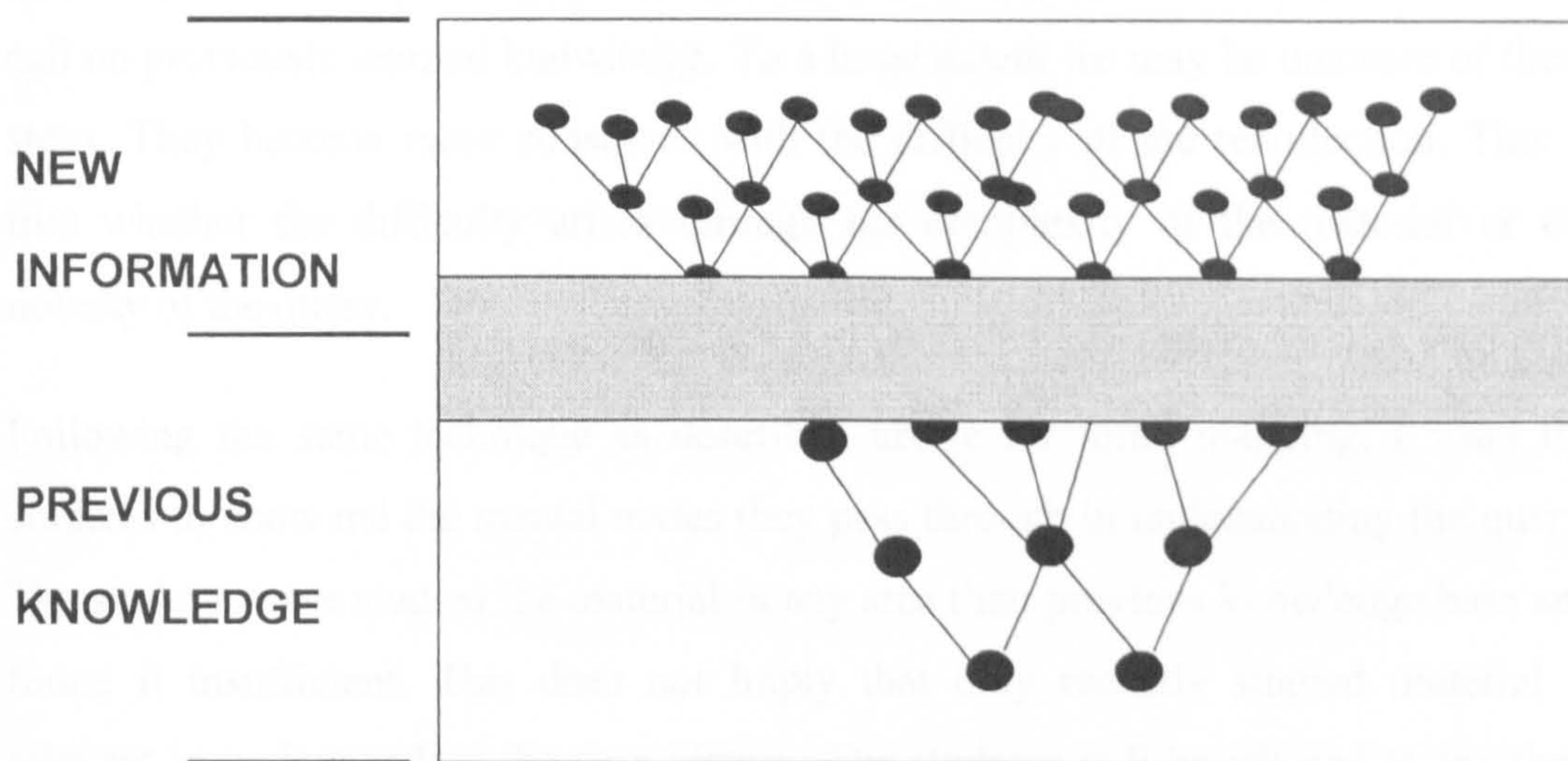
Represents the possible configuration of a student's cognitive network after addressing four case histories using retrieval concept mapping. It is assumed that a node can hold 5-9 bits of information, only some of these will lead to further branching.

The use of concept maps should enhance the ability to retrieve and the usefulness of information. This increase is primarily due to seeing the links between information not adding detail. I think this method should reduce (eliminate) the reported time lag in assessment performance associated with PBL.


What is a retrieval map?



First, what is a mind map? It is a planning aid. A particular idea or concept is queried. The procedure involves placing the key idea/concept in the middle of the page. Based on direct associations, branches are drawn from the central node to related nodes. Let's call it the central node. Based on direct associations, branches are drawn from the central node to related nodes. Let's call them level one nodes. The number of level one nodes will vary from one key concept to another, and from one individual to another. Branching continues from each of the level one nodes to concepts directly related to them; level two nodes. The procedure is continued in this fashion expanding to level three, level four, ... until the question has been adequately answered or the mapper's knowledge has been exhausted.



**Figure 4.2 Knowledge construction**

The links in this area (  ) are of particular importance. It is the connection between previous knowledge and new information. The concept map above and below these links may appear quite different. It is likely that some students will skip over previous knowledge and begin their maps with new information. They will be cautioned against this and at the same time asked to represent only those steps they find helpful.

What is a node? In general a node is a concept that can be represented by a word or two. If a node is a single fact then further branching from that node is not possible. It is possible to extend all networks of branching nodes to the terminus of a single fact, but in practice this is rare because that information is implicit and therefore offers little value to the mapper.

The effectiveness of this process lies in the ability of the mappers to see the picture unfold in front of their eyes. Much like group work, the picture increases the virtual capacity of the individual's working space. It allows them to manipulate the cognitive structure they have created without having to hold it in their minds. This



allows insight into indirect associations and the ability to pursue lines of inquiry without forgetting where they started.

Perhaps most important is that existing knowledge has been accessed and extended so that new information can be appropriately added. If prior knowledge is not activated, new information can be learned but not linked. This would greatly reduce the usefulness of the material.

Now, a retrieval map.

This map is an attempt to represent visually the mental steps that take place when we call on previously learned knowledge. To a large extent we may be unaware of these steps. They become more conscious with the difficulty of the recollection. This is true whether the difficulty arises through the complexity of the material or the novelty of the query.

Following the same technique as described above for mind mapping, I want the students to show me the mental nodes they pass through in understanding the query. The students have studied the material in any area their previous knowledge base and found it insufficient. This does not imply that only recently studied material is relevant in understanding the case history. The students will be advised to use their entire knowledge base, whether from the first day in primary school or last night in the library. I am not asking if they know the answer or what the answer is, but 'how' do they know.

Whether the retrieval maps produced are a useful and accurate representation will only be known to the individuals themselves. It is possible that their map will appear disjointed to an observer, perhaps fluctuating from extremely long jumps to tiny steps. The students will be made aware of these facts in an effort to have them understand that this process is only useful to them. Their concern is to become familiar with their own cognitive network, with the goal that greater familiarity will provide greater usefulness. The learners actually make far more steps than they will ever try to represent. This is not only understood, but it is strongly desired that they only visualise the steps they find helpful; perhaps branching points. It is primarily due to this search for helpful patterns (to the individual), that will cause the students



to practice the process before it becomes an unobtrusive tool instead of an assignment of its own.

What I want the students to do –

Preparation – the students should be familiar with mind (concept) mapping. It has been explained in the fashion of Tony Buzan. The medical faculty has advised students to become familiar with his work as a means of planning their investigations (learning). This research requires students to be cognisant of the concepts and branching patterns used in this process. While it is necessary for students to understand the process, it is neither necessary nor desired for them to use it during their investigation.

The students read the case history. Following their normal process; what are considered the main points are listed on the board and discussed in turn. They discuss the problem in light of their current knowledge, and any areas requiring further investigation are noted. When discussion of the problem has been completed, six to eight questions are generated based on gaps in knowledge highlighted during the discussion. The students individually seek answers to the questions posed.

Before the students return to their group for their final discussion of the questions posed. They will be asked to –

Reread the case history.

Using the previously described procedure, draw a retrieval concept map illustrating how they understand the problem. Tear off the bottom page of the form.

Using their notes, from the previous group meeting and subsequent investigations, make any changes and/or amendments desired. Tear off bottom page of form.

The top page of their retrieval concept map should be added to their notes. The two pages torn off are turned in upon arrival at their next discussion group.

## ASSESSMENT

This is a bit of a sticky wicket. The obvious choice is to compare the performance of students who use retrieval mapping to those who don't. Since this method will be

offered to one (i.e. group A) of the three groups of new med students, they can be compared to students in groups B and C. **[New medical students are randomly divided into three groups A, B, C. One of the groups would be the test group the other two would serve as the control. Since the proposal had not yet been accepted no designations had been made.]** It should be cautioned that students in group A who do not wish to participate do not provide an appropriate comparison. It is also advisable never to underestimate the resourcefulness and ingenuity of these young people. If one group is using a process they find helpful, the other groups will not only know, but be using the process themselves. It may very well be the strongest endorsement of this process to question groups B and C about their knowledge and use of it at the end of the trial.

The proposed, official form of assessment will be a critique by the students themselves. I will not use the standard, strongly agree – strongly disagree tick boxes. I think I can classify responses as positive, negative, or neutral. It is my hope that by asking for free writing responses, i.e.

- ◆ did you find the procedure helpful,
- ◆ did it become easier,
- ◆ did you begin to visualise nodes and links as you read through a new case history,
- ◆ did the mental or visual steps lead the process,....

I may actually receive an answer to a question that I never dreamed of asking. To a lesser extent, an evaluation of student performance by staff will also be sought. As a source of information for the staff and researchers about how and what students learn it will be very enlightening. The implications as to its long range benefit and use by the individuals can only come from questioning the individuals over time.



## WHAT BENEFITS DO I EXPECT FROM THIS RESEARCH?

### FOR THE STUDENT –

- ❖ Metacognition
- ❖ Mind mapping is a useful skill in planning any enquiry
- ❖ The idea of mind mapping (chunking and linking) is an aid to learning and retrieving information whether it is externalised or not
- ❖ Allowing the students to reflect on their cognitive processes within a loose framework gives them the ability to adapt it (personalise it)
- ❖ Retrieval concept mapping allows self assessment which provides; a practice session to further entrench ideas, a way of highlighting points of confusion (requiring further study)
- ❖ The layout of the concept map should enhance the usability of the information as applied to differing problems
- ❖ The process reinforces the positive aspects of careful reflection at various points during the problem solving process
- ❖ Familiarity with one's concept nodes allows more information to be held within the cognitive working space
- ❖ The students final concept map is retained in their notes and provides a visual reminder of how various concepts work in concert

FOR THE STAFF –

- ❖ The retrieval concept map is an individual effort and therefore allows some insight into the abilities of the individual rather than the group
- ❖ The process provides a way of addressing the various components of an inquiry without concentrating on order or on a specific answer
- ❖ The specific differences between the first effort (no notes) and the second effort (with notes) will highlight sticking points
- ❖ While the specific questions generated are not addressed by the concept map, it will reflect the input of the various questions (which questions are best)
- ❖ It provides an appropriate framework on which to hang side issues without confusing or distracting from the main idea
- ❖ It should positively reinforce the PBL model by further focusing the student on what they need to know, rather than on what the curriculum needs them to know

**[These proposed benefits, for staff and students, were primarily of a theoretical nature and could not be directly assessed.]**



FOR THE RESEARCHER –

- ❖ The linking and chunking of information is a fact of cognition. Does concept mapping utilise the natural comfort of these processes in a useful manner?
- ❖ Will the map of newly learned material will be more dense, more branched and take smaller steps than maps of previous knowledge?
- ❖ Can the tendency to retrieve an answer in a single step be consistently overcome?
- ❖ Can the process of writing down the steps be accomplished without detracting from or artificially enhancing the cognitive process?
- ❖ Will the specific questions remain distinct within the concept map?
- ❖ Will the main issues highlighted remain the bridge between new and old knowledge?
- ❖ Will particular branches of a concept map reappear in subsequent maps?
- ❖ If particular branches do reappear, in what way, if any, are they altered; shortened by familiarity, skewed to fit a new scenario?
- ❖ Will the retrieval maps operate within the working space of the students ( $\sim 7 \pm 2$  bits)?
- ❖ Does the process appear to enhance problem solving abilities?
- ❖ Do the students enjoy this highly individualised process of checking their knowledge base?

**[These proposed benefits to the researcher are addressed as applicable in Chapter Six.]**

## 4.2 Context Specificity

In my extensive reading regarding PBL, I have encountered the terms context specificity, content specificity, and encoding specificity. These terms have been used interchangeably to describe both positive and negative attributes of student learning.

On the one hand, a basic ingredient of PBL is the presentation of problems (scenarios) to initiate the learning process. These problems should encapsulate situations similar to those that would be confronted in professional practice. This similarity provides relevance to the material being covered, thereby enhancing the motivation of the students. It is further hoped that the salient features of a scenario, age and sex of the patient, medical history, and the order and intensity of presenting symptoms will manifest themselves into an internal template. This template, when subsequently activated, brings to mind the concepts, medical tests and even the diagnosis that became linked to it during undergraduate training. This process has been termed encoding specificity, or context specificity.

On the other hand, research in medical education is filled with examples of students who appear to possess knowledge they cannot use. The inability to transfer knowledge learned in one area to application in another is a consequence of context dependent knowledge. Contextually dependent knowledge is characterised by highly specific retrieval cues. Many times these retrieval cues are activated by periphery information having little or no connection to the underlying pathology of the presenting symptoms. These isolated bits of information are more closely affiliated with traditional education where the learning is compartmentalised into separate disciplines far removed from the arena in which it will be used. But this problem is not limited to traditional education. In PBL specific learning objectives are aligned, by administrators, with the presented scenarios. In an effort to cover more and more material, some learning objectives may be linked to only one scenario and this may provide a very limited access to the knowledge associated with it. This limited access can and has been called encoding or context specificity.

The acquisition, storage, and retrieval of information is not learning it is memorisation; learning is the appropriate application of information. This appropriate application is improved by addressing a number of scenarios that



stimulate the retrieval of the same information. These multiple scenarios not only provide multiple points of access to the information, but enhance the process of activating and mobilising prior knowledge.

These seemingly opposing views are not two ways of looking at the same phenomenon. Encoding or context specificity describes a variable position along a continuum. Whether the particular position being discussed is positive or negative depends on where along the continuum it resides. In an effort to distinguish between these two points I will use the term context dependent to refer to the negative aspect of situated knowledge.

### 4.3 Facilitator Training

The traditional lecture hall filled with hundreds of students and a teacher, is replaced by small groups with a facilitator. Staffing is one of the greatest difficulties to be addressed by a school instituting a PBL program. The change requires a number of small classrooms and a many-fold increase in staff. Finding and training staff is the most crucial step, certainly in the long run, when implementing a PBL programme. The number of facilitators needed has meant that practically, without exception, the staffing pool has been enlarged to include scientists from a number of disciplines. In many undergraduate programmes the non-medical scientists outnumber their clinical counterparts. Regardless of their background or experience all new facilitators must go through training. The practising clinician with years of experience lecturing in a traditional medical school may be the most difficult student. But it is likely that all of the new staff will be products of the traditional didactic educational process.

No graduates have yet emerged from the Glasgow programme, therefore, all elements of the programme including facilitator training are still evolving. Facilitator training at Glasgow and in most PBL Medical Schools, is divided into pre-clinical, years 1 and 2, and clinical. The difference between the two types of training is largely dealing with the hospital environment and its propensity to change.

Facilitator training for the pre-clinical years begins with a plethora of resource material from the Medical Education Unit. This resource material, primarily a collection of selected papers on PBL, serves as an introduction to the process and, for the uninitiated, brings to mind a number of questions like:

*If I don't provide the students with the correct answer how do I keep them from continuing along the wrong path?*

*How can I keep the dominant personalities in check while promoting an open discussion?*

*Since the students decide on the questions to be answered, what if they don't cover all of the learning objectives?*

*What if the students return for the debriefing and they all have the incorrect answer to a particular question?*

These training sessions are run by well qualified experienced facilitators who are, no doubt, more amused by some of the questions of these would-be facilitators than they are by some of the students' questions. They realise that if these trained scientists experienced one of these small group sessions first hand, most of their questions would disappear. Nevertheless they answer the questions while they are foremost in the minds of their non-traditional 'students'. In an effort to provide insight and to mirror the training process, I will address the questions posed.

*If I don't provide the students with the correct answer how do I keep them from continuing along the wrong path?*

The short answer here is you don't. During the brainstorming phase of the process, the students should pursue any line of enquiry that seems appropriate to them. If certain aspects of the scenario are not being addressed the facilitator may interject them into the discussion, but what the students do with the pieces is up to them. This is not the traditional classroom and the students are aware of the difference between a guess and a fact.

*How can I keep the dominant personalities in check while promoting an open discussion?*

On the macro level this question is not as difficult as it seems. In the traditional classroom you begin to call on anyone but the student who always has his hand up, but they still end up answering half the questions. In the PBL group you call on someone who hasn't been involved or you ask the rest of the group to comment on



the statements just made. These groups have a somewhat collective mind and if you supply hints to the preferred behaviour they will respond.

On the micro level the answer is not so easy. In any social situation some personalities dominate. Even if, through facilitator intervention, their actual airtime is constrained to their proportional increment, they will dominate by force of presence and conviction of delivery. For the most part, this is a fact of life that the students will encounter throughout their career, so this becomes part of their training. In facilitator training you deal with this problem only at the macro level.

*Since the students decide on the questions to be answered, what if they don't cover all of the learning objectives?*

If the scenarios are well written and the learning objectives well matched, this is not much of a problem. For a number of reasons, including those just mentioned, most of the learning objectives are highlighted as main issues during the initial discussion by the students. If an objective is missing from the final agreed questions, the facilitator may ask, how do you explain....

*What if the students return for the debriefing and they all have the incorrect answer to a particular question?*

Proper questions at this level are general and open ended; and these are highly capable, strongly motivated students. If two of the students were to return with the wrong answer it would be very surprising. It is not conceivable that half of the students would have found a wrong answer unless there are serious resource problems. The students will return with the correct answer and the facilitator need only address their understanding at an appropriate level.

Facilitator training continues with a video; an expert tutor and an experienced PBL group demonstrate the process. At this point the trainees are somewhat familiar with the basics and can examine some of their particular concerns in detail. The video will not answer all of their questions but will deepen understanding. Those in charge will continue to answer questions throughout the training process.

The trainees now form their own small group and are given a problem to address in the PBL fashion. I can comfortably say that this will be the most dysfunctional group these facilitators will ever see. A few weeks hence they would never tolerate the posturing and purposeful manipulation of process in which they are about to engage. This role playing does serve a purpose. Despite not being able to help themselves in the short term, in the long run they do gain some insight into group dynamics and the run through helps to establish the order of the 'Glasgow Steps'.

In the next phase, trainees are paired with experienced facilitators and sit in, with student permission, on actual PBL groups. In most cases the trainee watches an entire session and then returns and may act as the facilitator for the debriefing at the next session. The trainees may continue to observe these sessions until they feel comfortable enough to proceed on their own. New facilitators are matched to a few expert tutors who continue act as a resource as long as necessary.

As previously mentioned these undergraduates are very good students and many facilitators find that they have more difficulty in changing their own behaviour than in changing that of their students.



*The proposal was accepted.*

*The test group was group C.*

*Two lectures were scheduled, mid November and mid January.*

*Handouts for group C (the actual group allocated to me by the administrators) to be dispensed mid November, early December, mid January.*

*Main issues, questions and concept maps to be collected from group C for 10 scenarios. Collection to begin immediately after the second lecture (mid January).*

*The process would be assessed via questionnaires, interviews and final exam scores (exam scores to be supplied by the Medical Faculty).*



## Chapter Five

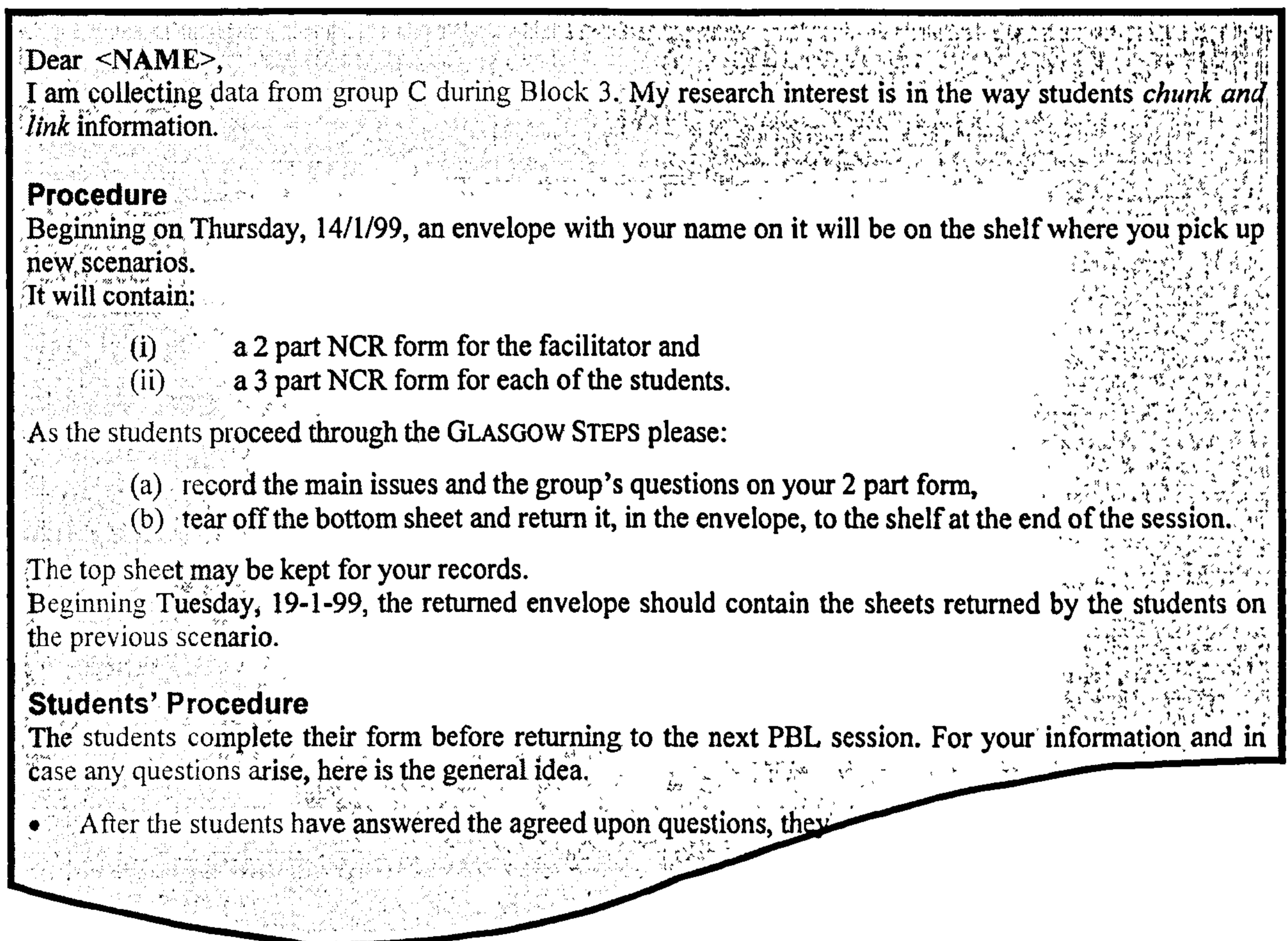
### *Data Collection*

New medical students at Glasgow are randomly assigned to one of three groups, A, B or C. Each of the three groups contained 81 or 82 students and were as homogenous as possible. The test cohort allocated to me was group C, 82 students. Within group C the students were further divided into nine PBL groups. Data collection began January 14, 1999. It was accomplished by dropping off envelopes containing a blank form and a personalised instruction sheet for each student and facilitator in group C. The facilitators returned the completed forms at the end of their PBL session. I had no direct contact with the students from the time data collection began until after their final exam.

I had lectured the students twice and given them handouts on three occasions (Appendix A). The main points I wanted to convey to the students were; we learn by association, the chunking and linking information is a cognitive fact, the basics of concept mapping, and that concept maps prepared in the manner described are highly individualised and should not be compared; their strength is in what they mean to their constructor.

## 5.1 Facilitators

A few days before data collection, each facilitator received a personalised information and instruction sheet. A copy of this correspondence can be seen in Appendix B, an excerpt is shown below, Fig. 5.1.



**Figure 5.1 An excerpt from correspondence to facilitators.**

As a new scenario unfolds, the students record the main issues highlighted by the scenario. The process continues through a discussion of each of these issues, referred to as a 'brainstorming' session, at the end of which the students generate questions that they will answer at their next PBL meeting.

The facilitators were asked to record the main issues and the questions on their form and tear-off the bottom sheet (to be returned in the envelope). These were not additional duties for the facilitators. They have a mental, if not a physical list of the main issues before the session begins and of course, they record the questions.



Two of the sheets returned by facilitators have been reproduced and are shown below; more examples may be seen in Appendix B.

## SCENARIO 2

Mrs Johnstone telephones Dr Green a few days after her most recent visit to the surgery. She emphasises how desperately tired she is feeling and tells Dr Green that she thinks that "she must be lacking in something" to have so little energy. She asks Dr Green if she can have a test to try to find out if her "system is run down". Dr Green decides to ask Dr Grey's advice. He comments that "in the old days they used to prescribe 'nerve tonics' which sometime contained vitamin supplements, particularly vitamin B1". He goes on to say that "there may even have been some science in this, bearing in mind the fundamental biochemistry of energy metabolism".

### PBL Group 26

#### Main Issues

Vitamin B<sub>1</sub> (supplements)

Biochemistry of energy metabolism

Tests

'Nerve tonics'

Tiredness

#### Questions

1. Give a brief overview of the biochemistry of energy metabolism.
2. What are the components of a healthy diet (include food source and function)?
3. What is a vitamin and why is vitamin B<sub>1</sub> necessary?
4. What are the common causes of tiredness?
5. How do you determine the cause of tiredness and what are the possible treatments?

### PBL Group 29

#### Main Issues

Vitamins

Energy metabolism

System – rundown

Tests

"Tonics"

Placebo

Patient control

#### Questions

1. Review the process of respiration and energy metabolism.
2. What is required in a balanced diet and what effect do they have?
3. What is the role of vitamins in the body (deficiencies and overdoses)?
4. What are the common causes of fatigue?
5. Why is in-depth history taking and examination important?

**This information was collected from 9 facilitators for 10 scenarios.**



## 5.2 Students

The students had been made aware of the concept mapping process and the routine they were to follow. At the beginning of each PBL session during the period of data collection, the students were given a personalised instruction sheet and a blank 3-part NCR (no carbon) form. As they removed the new forms and instructions, they placed their completed maps in the envelope provided.

Green that she became a "vegetarian" 10 months ago "for a variety of reasons". Dr Green asks Aileen to keep a diary of just what she eats every day and to bring this back in 2/52 in the hope that it will give her a better idea of the extent of the problem.

NAME>

When you have finished answering your questions put away your notes and books.

- ❖ Turn your form to landscape position and put your name and matric. number in the corner.
  - ❖ Reread the scenario.
  - ❖ Use the 'patient' name as the central node, it represents the entire scenario.
  - ❖ In 'mind map' fashion expand from the central node.
  - ❖ Expansion should be done one level at a time.
  - ❖ Use all your knowledge to explain the scenario, whether learned in the last week or in primary school.
  - ❖ Try to limit concept nodes to a couple of words and/or symbols; but this is your map and how you choose to represent the ideas is up to you, it should prompt your memory and if that requires a list or a graph at times that is up to you.
  - ❖ When finished tear off the bottom page of your form.
- 
- ❖ Take out your notes and make whatever additions or corrections you like.
  - ❖ When finished tear off the bottom page of the form.
- 

The top page should be part of your notes for this scenario.

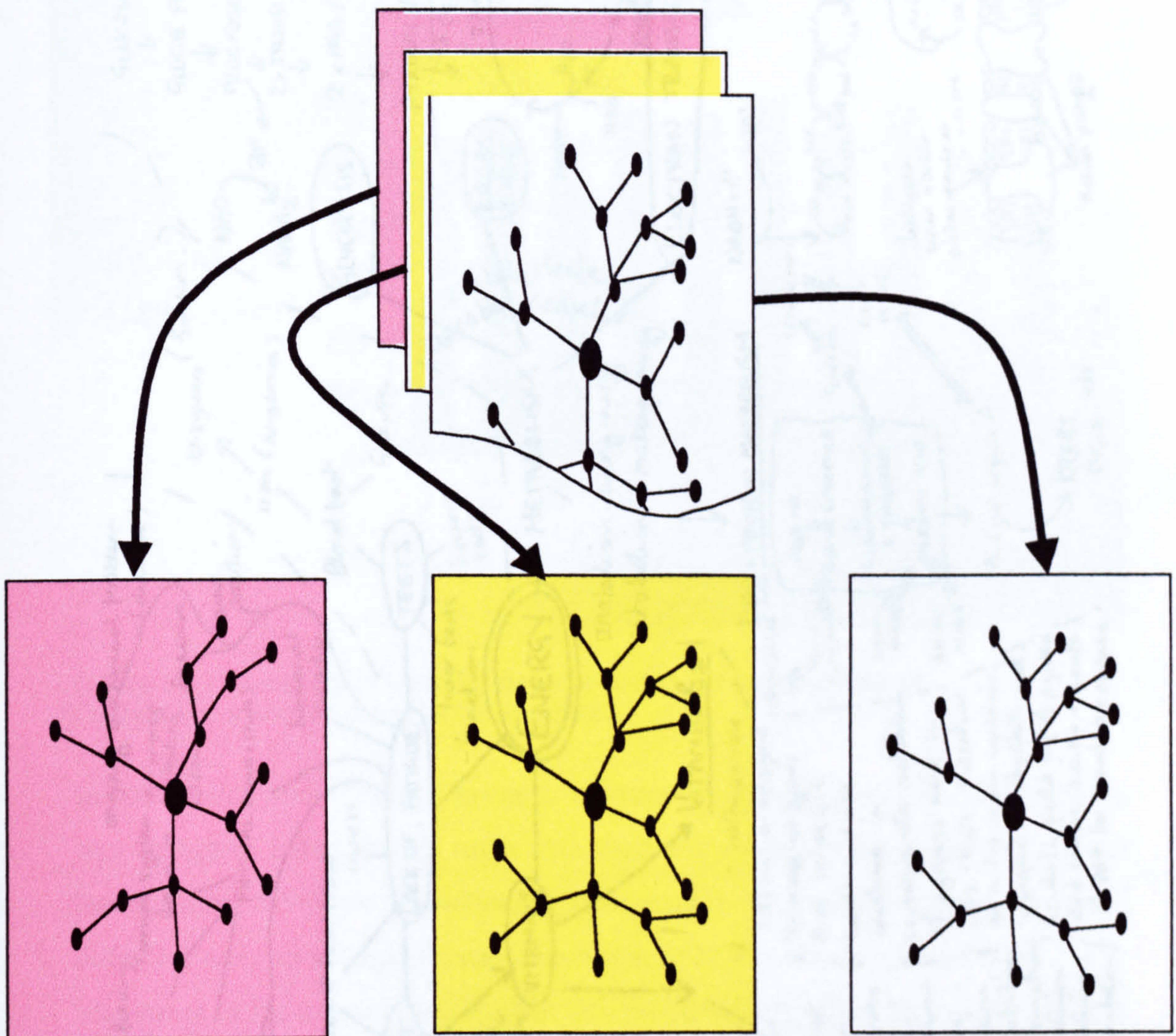
At the beginning of your next PBL session place the t

NK YOU

Figure 5.2 An excerpt from the students personalised instruction sheet.



An excerpt of the instruction sheet may be seen in Fig. 5.2. Following their normal habit, after beginning a new scenario and proceeding through the 'brainstorming' and question generation; the students would answer all of the questions in their own time before returning to the next PBL session. After the questions had been answered the students followed the instructions supplied and utilised their NCR form as shown in Fig. 5.3.



**Figure 5.3 An illustration of technique using the 3-part NCR form**

The form was used by the students to complete maps; pink sheet – no notes, yellow sheet – collected completed map, white sheet – students completed map.

The students were asked to show me, via a concept map, how they understood the scenario. An initial effort was made without the use of their notes. Then the bottom sheet of the form was torn off (pink). They then continued their map using any and all information available to them. When they were satisfied with their map they tore off the bottom page of the form (yellow). The top sheet (white) was retained by the

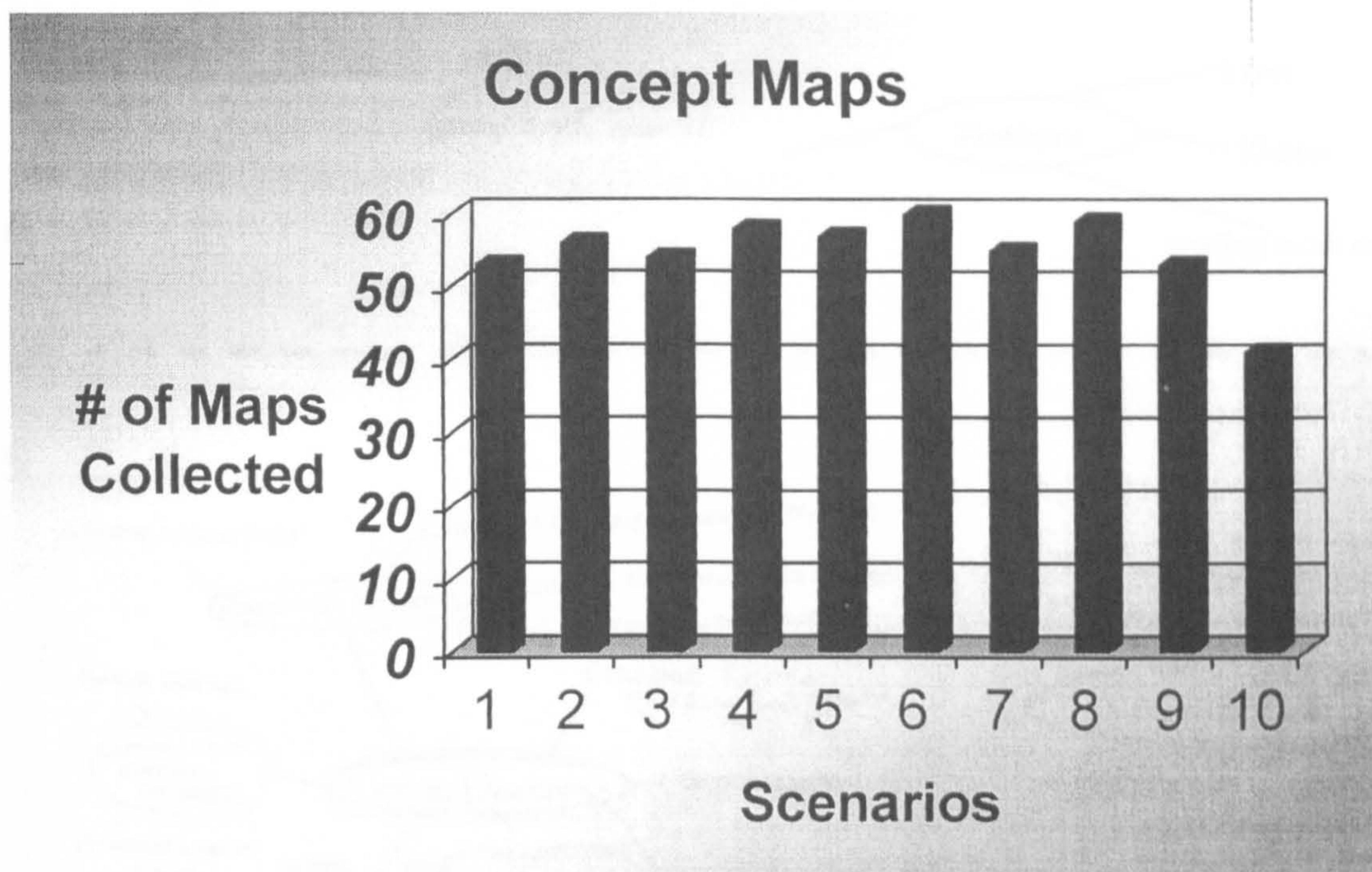






students for their notes. At the beginning of their next PBL session the completed yellow and pink sheets were placed in the envelope provided. One of the collected maps is shown in Fig. 5.4, other examples may be seen in Appendix E.

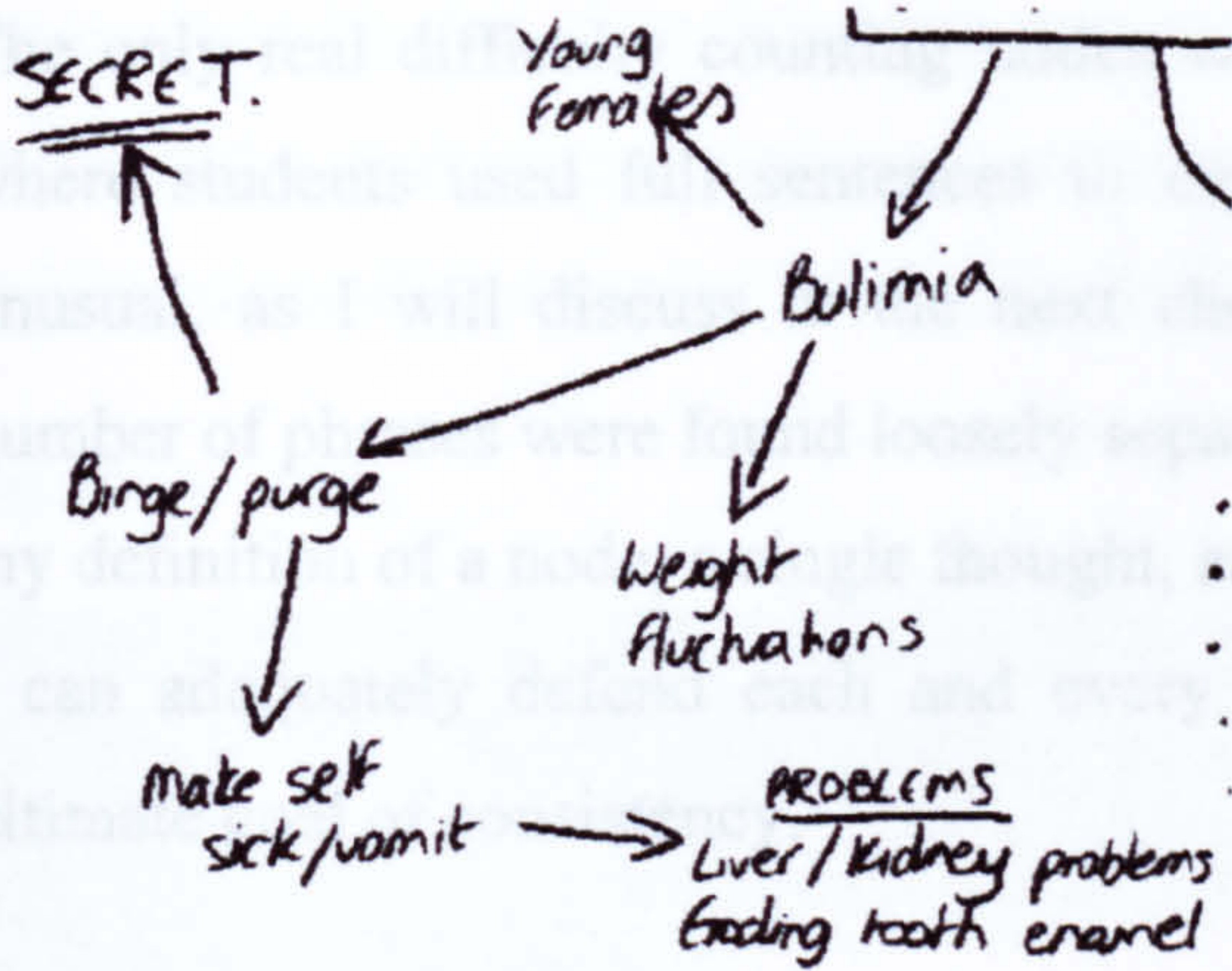
The maps were collected for ten scenarios, a total of 546 maps in all (Fig. 5.5).



**Figure 5.5** The number of concept maps collected out of a possible 82 Concept Maps were collected for ten scenarios.

In anticipation of the analysis to come, information regarding general map attributes was collected. I divided the maps into their basic components, nodes, links and layers. Figure 5.6 shows subsections of three maps to illustrate this scoring method. I defined a node as a single thought regardless of how it was expressed (Fig. 5.6A). The layers of the map were defined as the number of links from the centre, the 'key concept' (Fig 5.6B). As I collected and recorded these features for each of the maps a problem arose with drawings that required clarification. I was actually a bit surprised that the maps did not contain more drawings but there were a sufficient number to require some decision as to how to count them (Fig. 5.6C). My primary aim was to be consistent, so I decided to count the drawing itself as one node and if the drawing was labelled then each of the labels counted as one node. I did wonder if I was giving sufficient credit for the drawings but they were a minor factor and I could not justify some subjective assessment as to how many thoughts comprised the sketch.



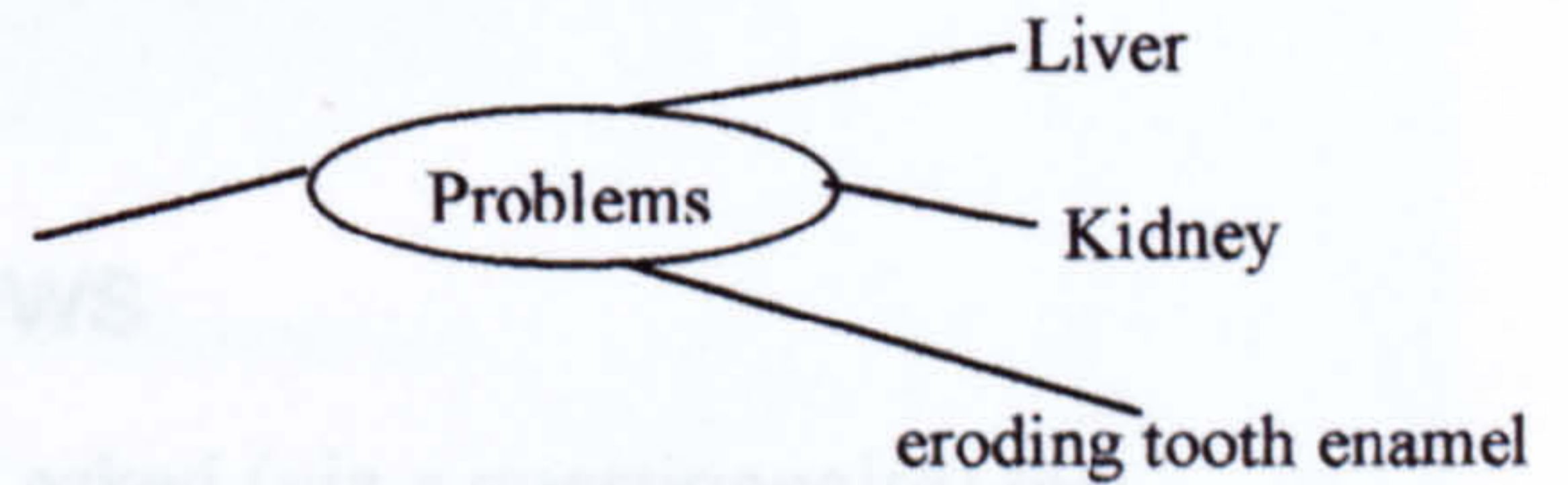


**A** A node is a single thought no matter how it is expressed.

Bulimia – one node

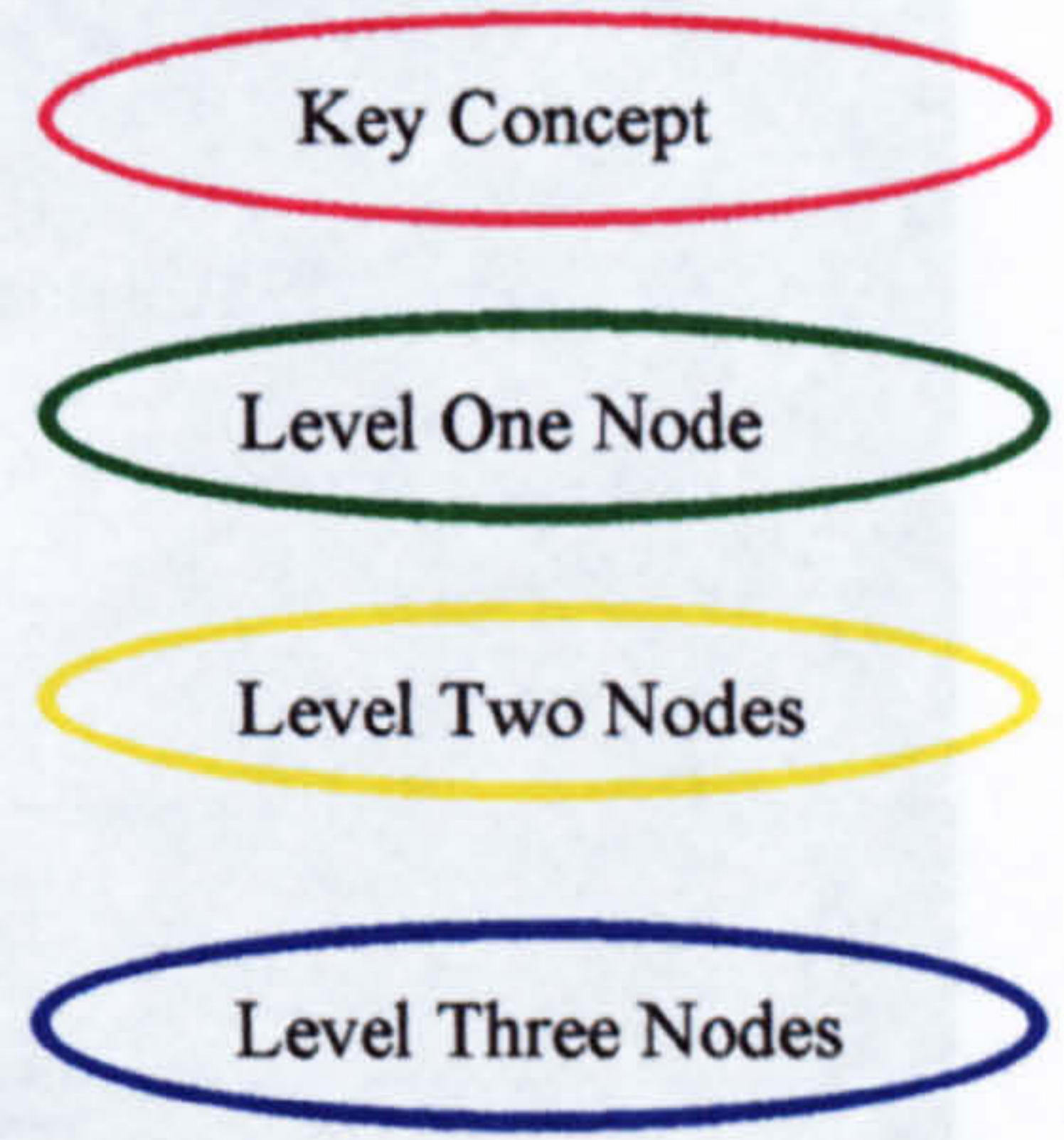
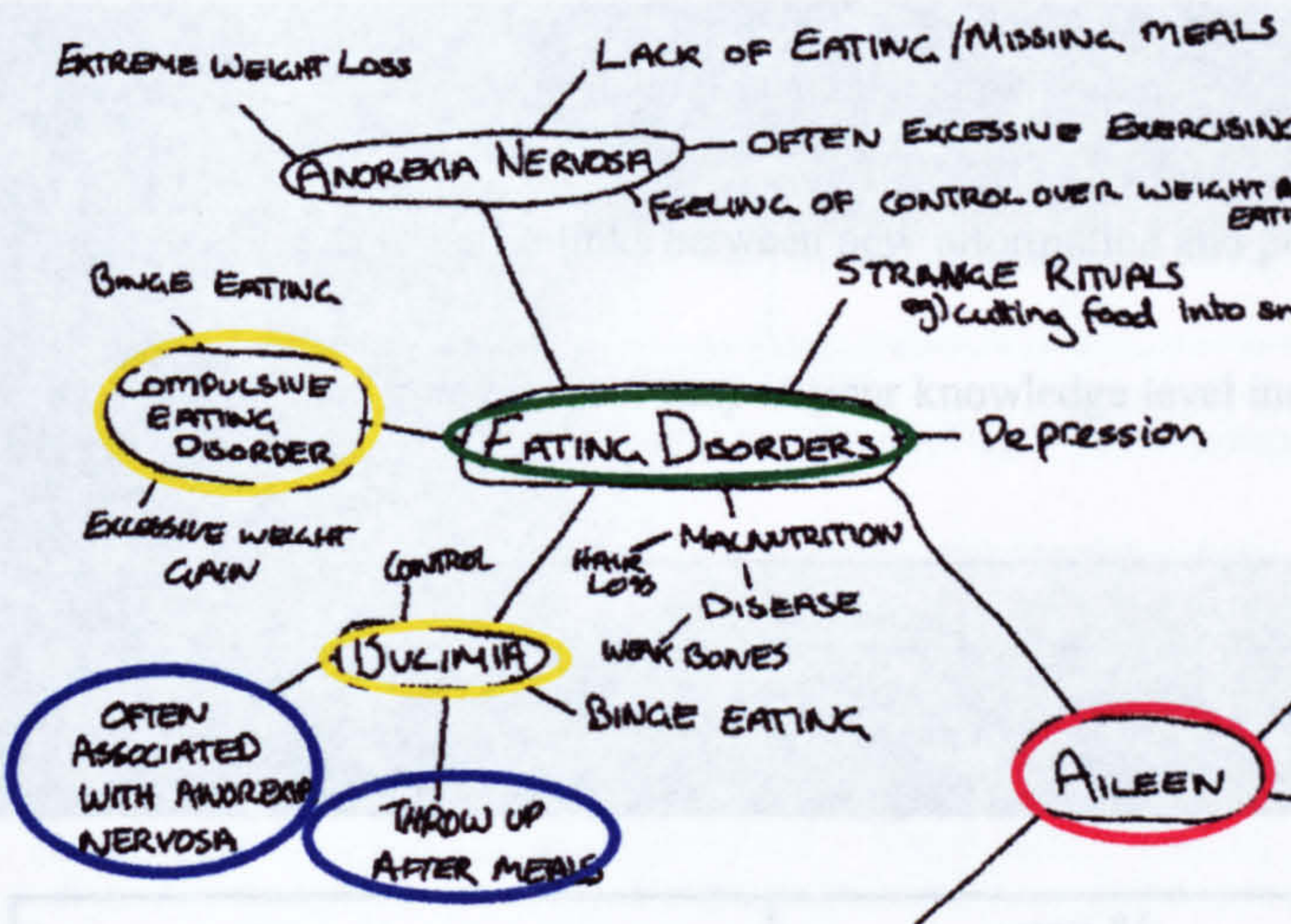
Binge/purge – each of these could be a node but in this context, one node.

Problems.... I counted as if..



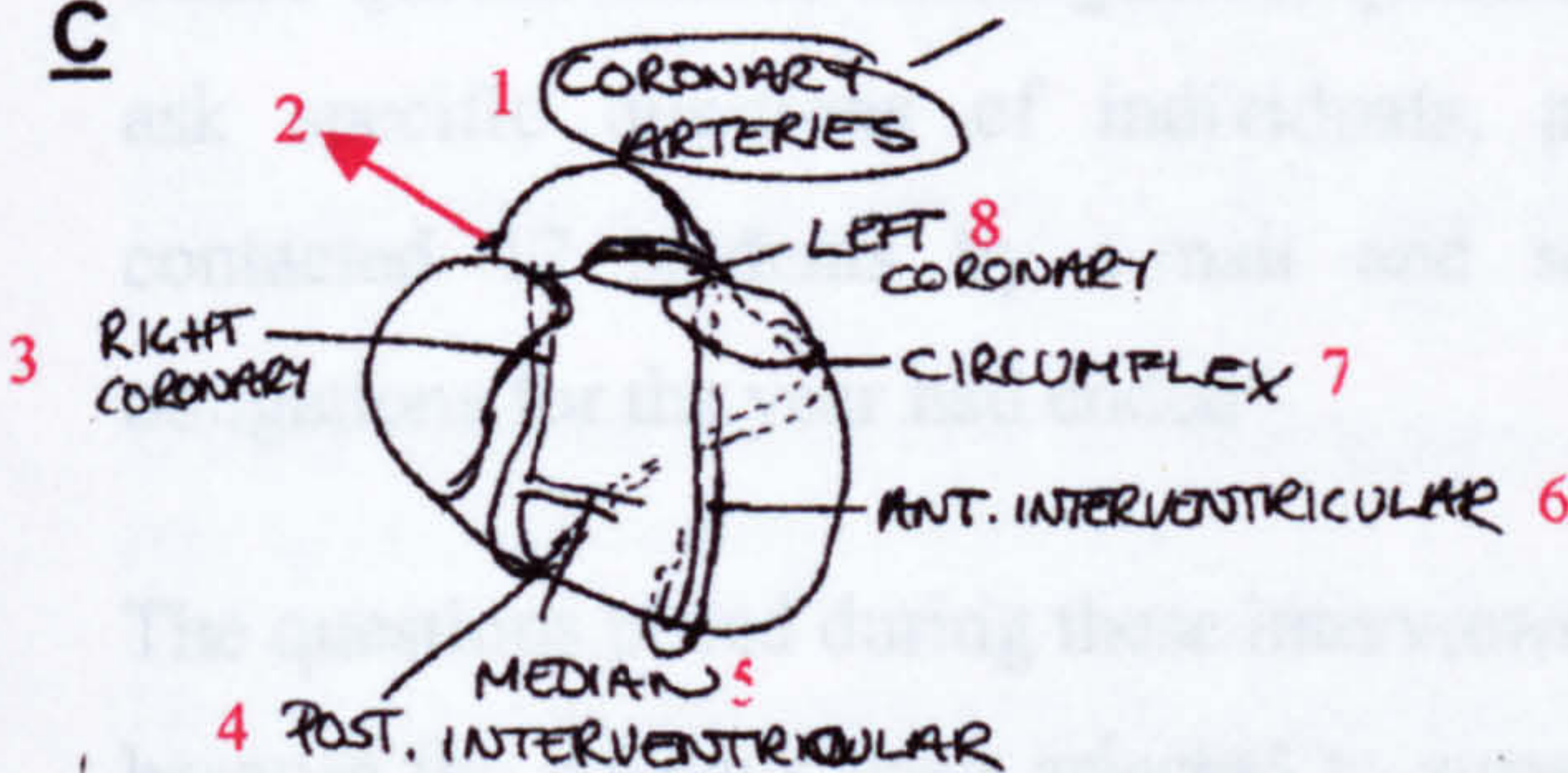
**A**

**B**



**B** Starting from the key concept the maps branch to level one nodes and from level one to level two and from level two....

**C**



**C** In quantifying map attributes I had to establish a consistent rule for drawings. I counted the drawing itself as one node (2) and each of the labels as a node.

Figure 5.6 Counting nodes and layers.



The only real difficulty counting nodes was found in the periphery of some maps where students used full sentences to express a thought. I found this somewhat unusual, as I will discuss in the next chapter, but the problem appeared when a number of phrases were found loosely separated by commas. In these cases I recalled my definition of a node, a single thought, and did the best I could. I do not know that I can adequately defend each and every decision but I stand solidly behind my ultimate goal of consistency.

## 5.4 Questionnaires and Interviews

During the final week of their academic year I asked (via a questionnaire) the students in group C the following questions.

On concept maps

Did you keep your concept map for later study and review?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Did you begin to visualise links between new information and previous knowledge?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Did you continue to revise your map as your knowledge level increased?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
COMMENTS _____		
_____		
_____		

	yes %	no %
keep concept map	88	12
visualise links	63	37
revise your map	20	80

**Figure 5.7 Concept map questionnaire**

The results of the questionnaire expressed as a percentage.

These questionnaires asked general questions. In order to gain more insight and to ask specific questions of individuals, personal interviews were conducted. I contacted 12 students by e-mail and set up interviews after their academic obligations for the year had ended.

The questions posed during these interviews varied considerably from one to another because the students were selected to answer specific queries. Four of the students were asked to produce a concept map based on one of their previous scenarios. Three



were asked if, and if so how, the process had helped them (I was concerned that some of the students had not produced very good maps). Six of the interviewees had exhibited peculiar mapping attributes about which they were probed.

On study skills

Do you use Mind Maps (concept maps)?	Yes <input type="checkbox"/> No <input type="checkbox"/>
Do you study and reflect on the answers you have found?	Yes <input type="checkbox"/> No <input type="checkbox"/>
Do you try to understand the scenario in light of your new information?	Yes <input type="checkbox"/> No <input type="checkbox"/>
OTHER _____	
_____	
_____	

	yes %	no %
use concept maps	33	67
study answers	80	20
understand scenario	93	7

**Figure 5.8 Study skills questionnaire**

The results of the questionnaire expressed as a percentage.

**Questionnaires were collected from 74 of the 82 students in group C.**  
(This was a 90% return.)

All of the students were questioned about the mapping process and whether they had continued it after data collection. They were asked about mock exams, which had been a point of contention that spring.

**Twelve personal interviews were conducted, 20% of the test cohort.**



*There were 546 two-part concept maps collected.*

*The quantitative components of each map, nodes and layers, were recorded.*

*During the final week of the academic year a questionnaire was administered and 74 sets of responses were collected.*

*Following the final exam twelve of the test subjects were interviewed.*

*The final exam scores were supplied by the medical Faculty.*



## Chapter Six

### *Analysis*

From the moment of conception the goal of this research was to enhance the academic performance of the students who participated. This, then was the search for the Holy Grail. Was such an effort both naive and egotistical on my part? Perhaps, but research in general can be classified as such and may we always strive for the panacea of education.

The problem of such a goal is finding a method or process that works across the breadth of human diversity. It may seem simple then to compare the exam results of those who participated to the results of those who did not. This obvious and elegantly simple path will be explored, but there are a number of peripheral issues that bear examination. For example there are a number of issues pertaining to the PBL process to be evaluated. In addition Concept Mapping, utilised here as a highly personal 'learning tool', has been and continues to be marketed as a method for introducing new ideas and as an alternate form of assessment.



An extensive examination of these peripheral issues is not only warranted on their own merit, but together PBL and Concept Mapping set the stage on which this play is cast. They describe the reaction conditions under which this panacea was sought.

## 6.1 Problem-Based Learning

As has been previously described in Chapter Three, PBL is gaining world wide acceptance as an alternative to the traditional education process. The diversity exhibited in its interpretation is to some extent necessary as it is applied to various disciplines. Despite the variety inherent in the practical application of the PBL process there remains substantial common ground and therefore a number of common concerns.

What happens to the 'main issues', in the minds of the students, that serve as points of impetus during the 'brainstorming' phase of the process?

How does the number and the precise wording of the questions affect the information gathering and long-term learning goals of the students?

How does the personality and attitude of the 'Facilitator' affect the small group process?

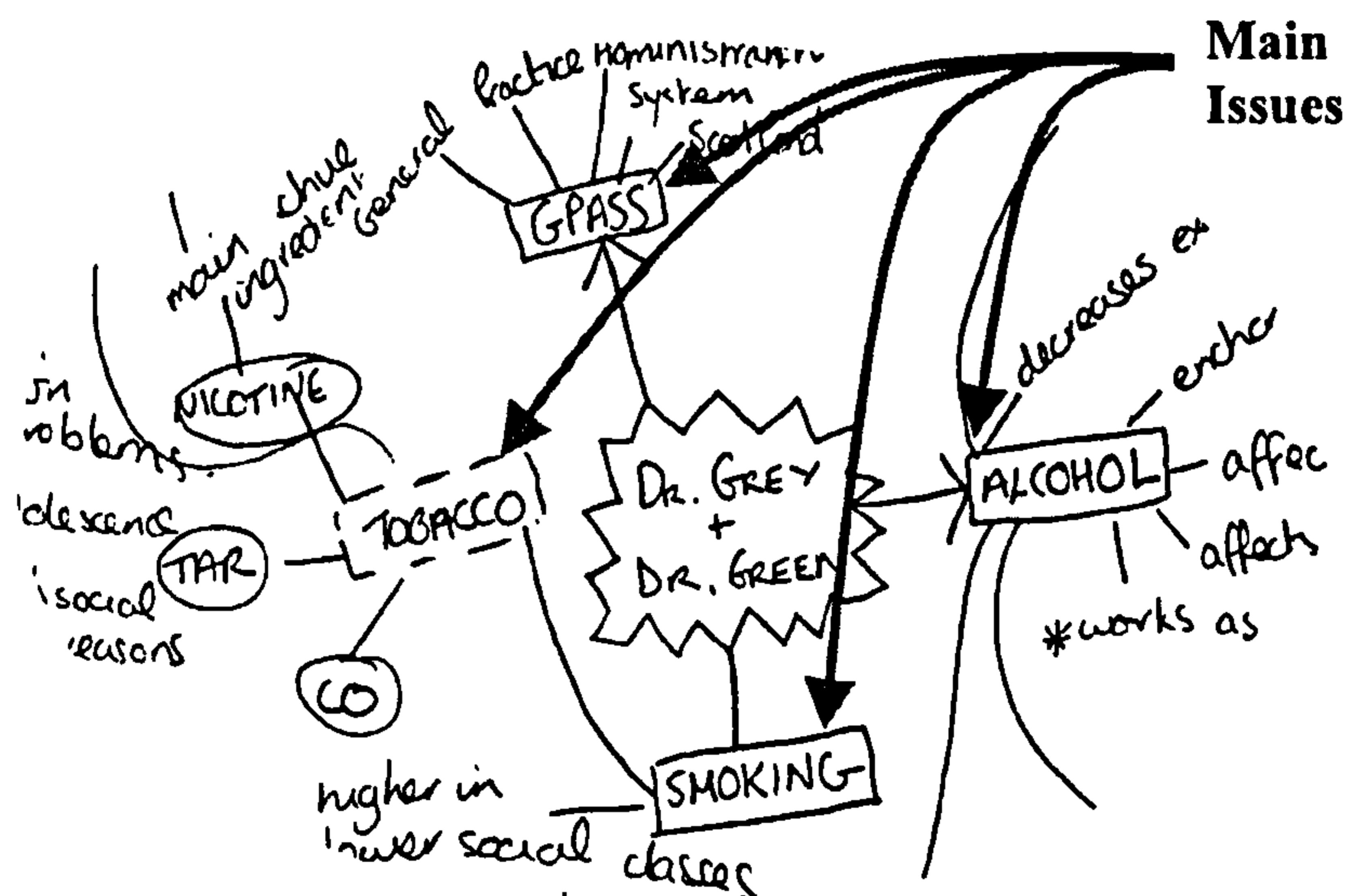
### 6.1.1 Main Issues

The 'main issues' are inherent in the scenarios that initiate the PBL process. They begin as a list of general concepts in the mind(s) of the author(s) of the scenario. In many cases the scenarios are not written but selected from real life experiences. Even when the scenarios are selected they are done so based upon the perceived main issues which they encompass in the mind of the selector.

As I have previously described concepts are emergent. They should arise as a result of assimilating a substantial data-base. I was concerned and curious as to whether these labels (main issues), once selected would remain intact in the minds of the students and subsequently manifest themselves as conspicuous nodes in the collected concept maps. Theoretically I wondered if these labels would serve as pre-selected anchors for the specific and detailed information the students would subsequently study.



The first question to be answered was whether the 'main issues' could be traced from the 'brainstorming' process to the collected concept maps. This was not found to be a difficult task, in fact a cursory examination sufficed to confirm this notion. Figure 6.1 shows a portion of a concept map and illustrates what is typical for a majority of the maps: the 'main issues' are highly apparent.



**Figure 6.1 Main Issues**

The Main Issues generated during 'brainstorming' are prominently placed in the student's maps.

Having established that the 'main issues' do in fact remain intact in the minds of the students, the next question is does it matter? A little thoughtful reflection on my part, subjective analysis, yields the following.

The nature of the PBL process is to use a series of real life scenarios to provide the impetus for learning and understanding. The depth of specific knowledge and the breadth of the symptoms being integrated are a consequence of the layering of scenarios in the long run. The Glasgow Medical School, like most, uses a systems approach as the framework on which to hang its curriculum. From both a historical and logical perspective this is a most sensible approach. The academic year at Glasgow is divided into Blocks which encompass 10 scenarios over five or six weeks. These Blocks are centred on a particular theme and it is inevitable that the scenario writers would have a list of concepts that the Block of scenarios should encompass. It is a great strength of PBL that the precise link between these concepts is not stipulated nor are the concepts specifically defined. This allows the students to



explore and to utilise their individuality in putting the pieces together. In this way the highly personal idiosyncratic nature of learning is preserved.

I did find these 'main issues' prominently placed in the concept maps of the students. They occupied positions within the inner layers of the maps, primarily layers one or two. But they were located in these positions because that is where they belonged. It did not appear that the students selected these 'main issues' and then expanded their maps from there. The maps expanded from the 'key concept' (the scenario) in a thoughtful logical manner. It was my concern that the students would treat the maps as an assignment not as a learning tool. If viewed as an assignment they would try to think of what was needed to satisfy the assignment, not on learning the new material they were covering. The maps certainly varied with the individuality of the student who prepared them but seemed to be guided by an honest attempt to put the pieces of the puzzle (the scenario) together.

I had collected the 'main issues' from all nine PBL groups and found significant agreement between the groups as well as the prominent placement of these issues on the subsequent maps. I don't know that this was an unexpected result and I was pleased that the maps indicated a thoughtful not a formalistic construction. But, I did find something interesting. Although I am somewhat ambivalent in regard to its long range significance.

I began to examine the few instances where the PBL groups were divided as to the precise wording of a 'main issue'. The most striking example was found in the first scenario. The sheets collected from the nine PBL groups indicated that, four had chosen Mental Health as a 'main issue', four had chosen Mental Illness and one had opted for Mental Distress. There were 53 maps collected from scenario 1, of these 28 were from groups who had chosen Mental Health as a 'main issue' and 20 maps were from those who had chosen Mental Illness (Fig. 6.2).

This situation occurred on only a few occasions but, in each case, a similar pattern was observed. It is clear from the results shown in Fig. 6.2, that there is a very strong tendency for students to retain the original tag under which they file new information. I will make some further comments on this topic in the following chapter.



## Concept Maps

	Mental Health	Mental Illness	Other
Main Issues Mental Health (28 maps)	24	1	3
Mental Illness (20 maps)	2	14	4

**Figure 6.2 Selected Main Issues**

The previously selected Main Issues remained distinct in the collected maps.

### 6.1.2 Questions

As the individual group proceeds through the process, the students read the scenario, select 'main issues', discuss the scenario to the level of their current knowledge base and then generate a number of questions. From this point onwards the questions will drive the learning process. Because of their implied importance, administrators and staff have raised a couple of points regarding them.

- ◆ Does the precise wording of the questions affect the quantity or quality of the information gathered by the students.
- ◆ Does the number of questions affect the quantity of information gathered by the students.
- ◆ Will the answers to the questions remain intact in the concept maps prepared by the students (will each branch in the map be an answer to one of their questions).

As can be seen in Appendix D there is considerable variation between PBL groups in the style, wording and number of questions generated. Whether these differences are a result of the Facilitator or a dominant personality within the group can not be determined. No doubt it is likely to be a combination of the two.

Determining the quality of a question is highly subjective and in all but the most extreme cases fairly indefensible. The objective choice was to compare groups with different numbers of questions. My only yardstick on which to measure these differences were the collected maps.

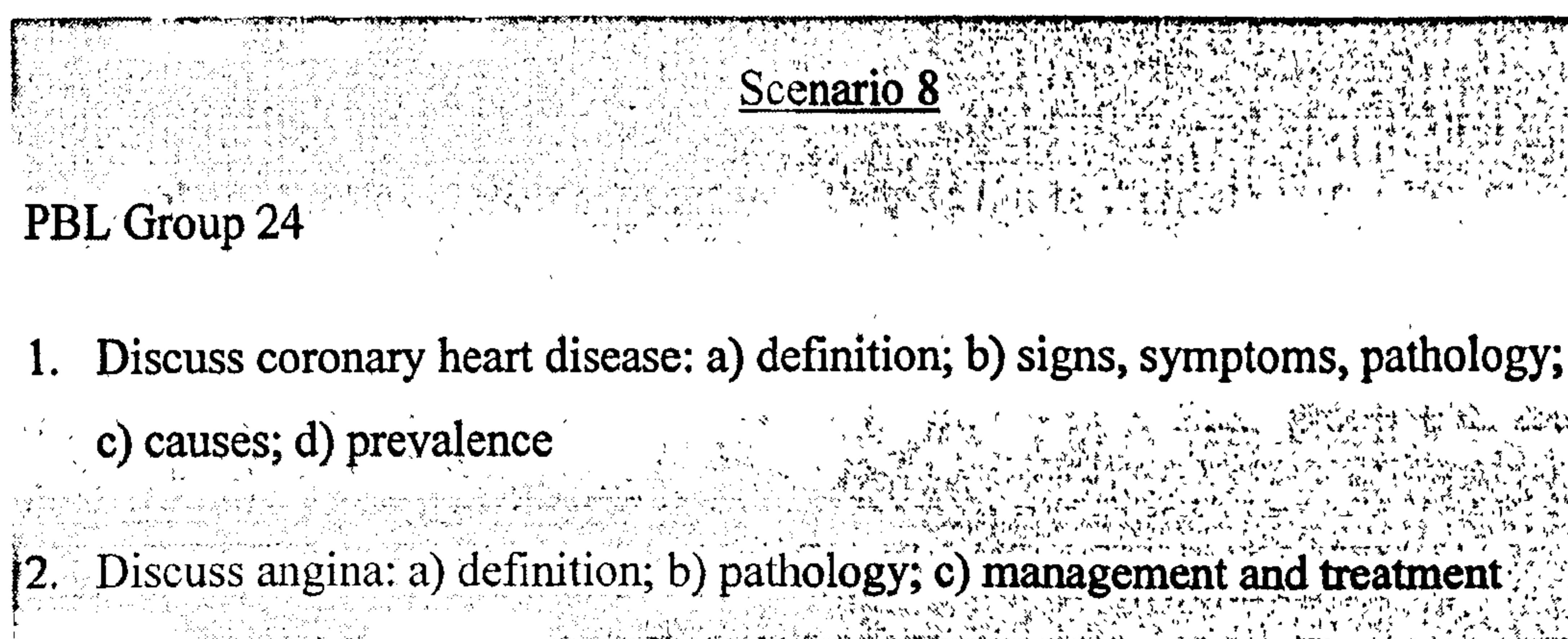


I will make further observations regarding the maps in Section 6.2. Here I only wish to evaluate the impact of the questions on the students' subsequent information gathering.

During this research 90 examples of 'main issues' and questions were collected. While analysing the data I found that I often correctly speculated which PBL group had generated the form. However my familiarity with the material was a product of a number of factors; the style and wording of the questions, the number of questions, the idiosyncratic nature of the facilitators (including handwriting) who recorded the data. The only factor that seemed appropriate for comparison was the number of questions.

I decided to compare the number of nodes on the concept maps of students from a group that had generated a few questions, with the number of nodes generated from a group with many questions. While I was able to make some comparisons that satisfied this goal, it was not straightforward.

The number of questions ranged from two to eleven. These were the extremes; over 75% of the forms contained four to seven questions. Comparing a group with four questions to one with seven is of arguable significance, an argument I do not wish to make, especially in light of the following example (Fig. 6.3).



**Figure 6.3 PBL Questions**

Student generated questions from scenario 8.



Conservatively you could estimate this to be seven questions and by any standard there are clearly more than two. If I used this example for any purpose it would be to compare the style of questions. In fact I was able to distinguish differences between groups based on the style of questions. Some groups preferred general, multi-faceted, open ended questions while others preferred simple, concise closed questions. It seemed reasonable to ask whether one of these two approaches succeeded in producing more nodes in the minds and maps of the students.

In order to verify any quantifiable difference between the groups I first have to prove that the instrument being used (Concept Maps) is sensitive to the differences being measured. I certainly found differences between individuals when I compared the number of nodes on their completed maps, (Fig. 6.4). However I further had to establish that these

	Scenario	Nodes
Student 202	4	83
Student 209	4	31
Student 234	4	46
Student 274	4	106
Student 278	4	79

**Fig. 6.4 Idiosyncratic Mapping**  
Note the variation in the number of nodes on maps created from the same scenario.

differences fluctuated in some manner consistent with discernible variations in the questions or the scenarios themselves.

I was surprised to find this was not the case. The personal nature of the concept maps manifested itself by establishing consistent differences between students. Therefore comparing students from one group to students from another group on the basis of the number of nodes in their concept maps would not be fruitful.

The only option seemed to be to compare the maps of a single student over a range of questions and scenarios. What I wanted to find was a PBL group that had an unusually low or high number of questions for a particular scenario. Then to compare those maps, to maps created from a scenario with an average number of questions. I explored a half a dozen situations as described; two of which can be seen in Fig. 6.5.

I did find some differences, but they did not seem to fluctuate in any characteristic manner from one scenario to another. I will make further comments on the characteristics of the collected Concept Maps in Section 6.2.



So it would seem that I have been unsuccessful in measuring an effect between different styles or numbers of questions. Maybe, but sometimes the answer is no. If the questions direct what and how much is learned, how can the answer be no?

From a subjective and objective examination of hundreds of maps I conclude that the students use the questions as very loose guides of what they should learn. Despite the differences in number and style of questions, the maps for individuals remained very similar in the quantity and quality of data recorded.

These are first year students who have recently come from school. Inevitably they are just beginning to expand their knowledge. They certainly take some hint from the scenario as to the depth of understanding necessary, but the specifics of the scenario are largely ignored. Instead the students generalise the scenario and ask ‘what is it they want me to learn here’? It is inevitable that students will try to anticipate assessment. As they proceed through their training, from pre-clinical to clinical years, breadth of knowledge may expand, the focus may shift to depth of understanding and the role of the questions may figure more prominently. At this point it seems that the students seem to know what is expected no matter how you word it.

Student 210

Student 217

Scenario	Questions	Nodes	Scenario	Questions	Nodes
1	6	45	1	6	23
2	7	47	2	7	68
3	11	44	3	11	86
4	5	46	4	5	71
5	6	47	5	6	47
6	3	46	6	3	69
7	4	-	7	4	57
8	2	44	8	2	75

High # of Questions →

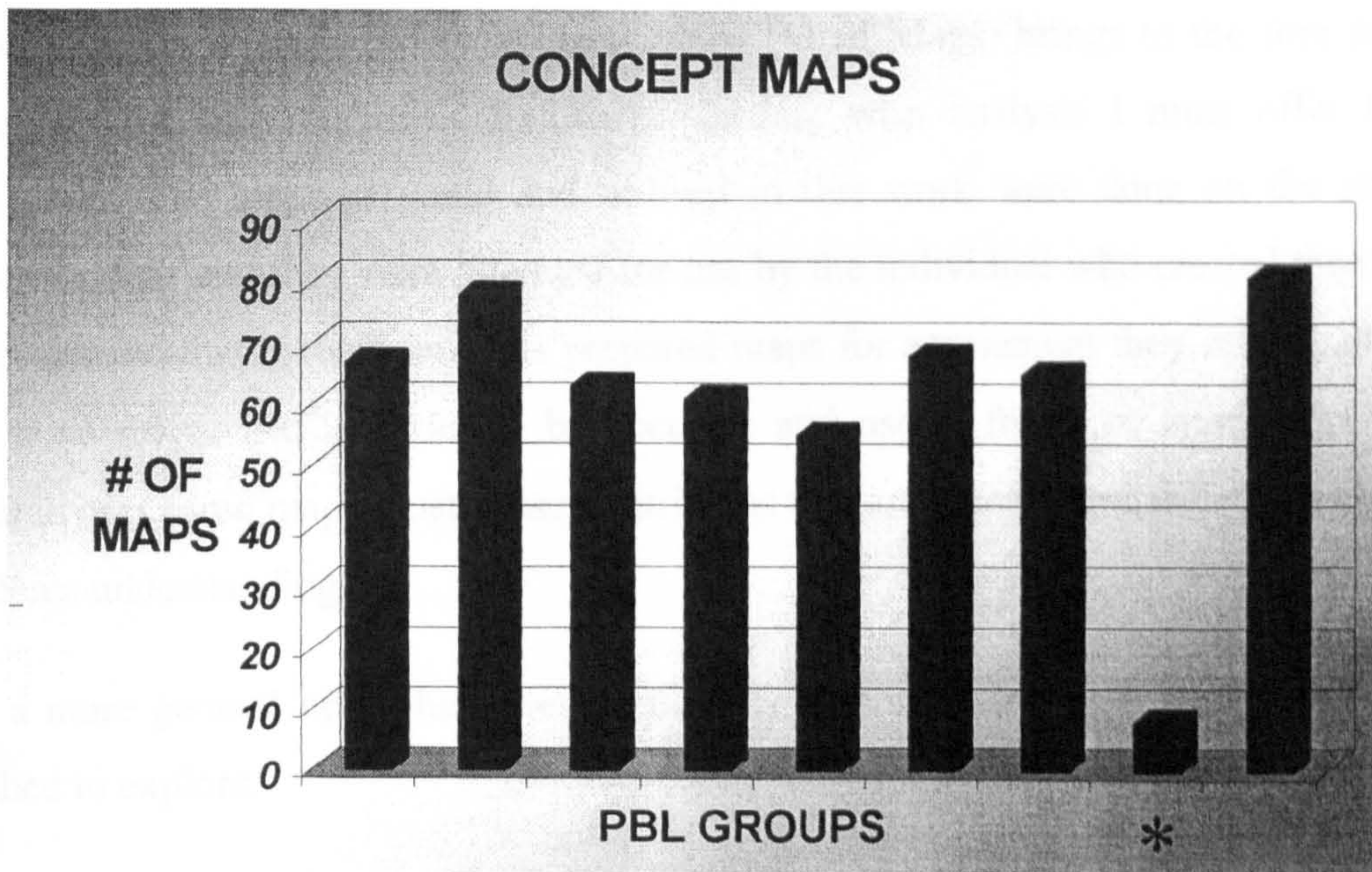
Low # of Questions →

**Figure 6.5 Nodes per question**  
 Compare the number of nodes generated by a high number of questions to the number of nodes generated from a low number of questions.



### 6.1.3 Facilitators

I had collected a total of 546 maps of the possible 820. Student participation in this research was voluntary, so an overall response rate of over 65% was most welcome. As I have mentioned, I was fortunate to have gifted dedicated students as my subjects. Participation of one of the PBL groups stood out. This group had nine members so that over the 10 scenarios there were 90 possible maps. Amazingly only eight were collected.



**Figure 6.6 Collected concept maps**

The number of concept maps collected from each of the nine PBL groups.

Whether this overt lack of participation (Fig. 6.6 \*) was due to the subconscious attitude of the facilitator or the semi-conscious attitude of one of the group members is unknown. While it seems clear that some unique factor was at work here, I am confident that the facilitator said all the right words and did not tolerate the wrong ones from the students. Despite the outward appearance that all was well, an undercurrent existed within this group an undercurrent, that manifested itself by a conspicuous lack of participation in this research. From my limited options, questionnaires and exam performance, I found nothing remarkable about this group. I use the example to highlight the unobserved potential that exists in these microcosms of society. In these small groups a facilitator or dominant group member can subtly influence the goals and desires of the group. By virtue of an uncomfortable



movement or a look (or the lack of one) covert desires can be conveyed. Despite the goal of most facilitators to remain as unobtrusive as possible, they should never forget their ability to influence their students, indirectly or even unwittingly.

## 6.2 Concept Mapping

The concept map as used in this research can be a powerful personal learning tool for the students. This was a primary message of this work; substantial subjective and objective analysis will support this position. However the expanding uses and importance being attributed to Concept Maps (Mind Maps) brings to the fore their reliability for such purposes. Before proceeding with analysis I must offer this disclaimer. The maps prepared and utilised in this work were done on the strict understanding that they were intended for use by the individual who created them. It is recognised that if these students prepared maps for assessment they might not be the same maps. But in order to be accurate and useful forms of assessment the naturally prepared maps must possess attributes that are a consistent reflection of the students understanding.

On a more general note, there were a number of anticipated map attributes that I wished to explore.

- ◆ Differences between the first map (no notes) and the second map (with notes) should highlight areas of concordant difficulty.
- ◆ The quantitative density of the maps should vary with the complexity of the scenario being mapped.
- ◆ The individual personality of the student will manifest itself by producing consistent branching patterns and overall layout.
- ◆ Concept Maps should be extensions of our natural cognitive chunking and linking, therefore most students will be 'good' (subjective analysis) at it.
- ◆ A judicial blend of subjective and objective analysis should provide some means of predicting student performance.

Each of these will be discussed in turn.

### 6.2.1 No Notes

Unfortunately this analysis was neither difficult nor time consuming; simply it could not be done. The mapping process I designed for the students was two-fold; first it



had to provide the researcher with useful data and insight into the way students assimilate new information, second it should reward the students with better understanding for time spent studying. Armed with the knowledge that one of the best ways to get a piece of information into your mind is to use it, not try to memorise it, I asked the students to do their maps in two parts. I was cognisant of the fact that with no controls on the students this would be 'soft data', but at the end of the day it would reap the greatest reward for the students. Here I am reminded of the old adage 'you can lead a horse to water, but you can't make him drink'.

During this research I collected 546 maps and I can recall no instances where I received only one of the two sheets, therefore  $546(2) = 1092$  maps. But the bottom (pink) sheet of the form did not appear to be a mapping effort without notes. Why? *"Sorry...I used a felt tip pen, it didn't show up on the bottom sheet"; "I forgot to tear off the pink sheet until I was almost through"; "the form didn't work"...*

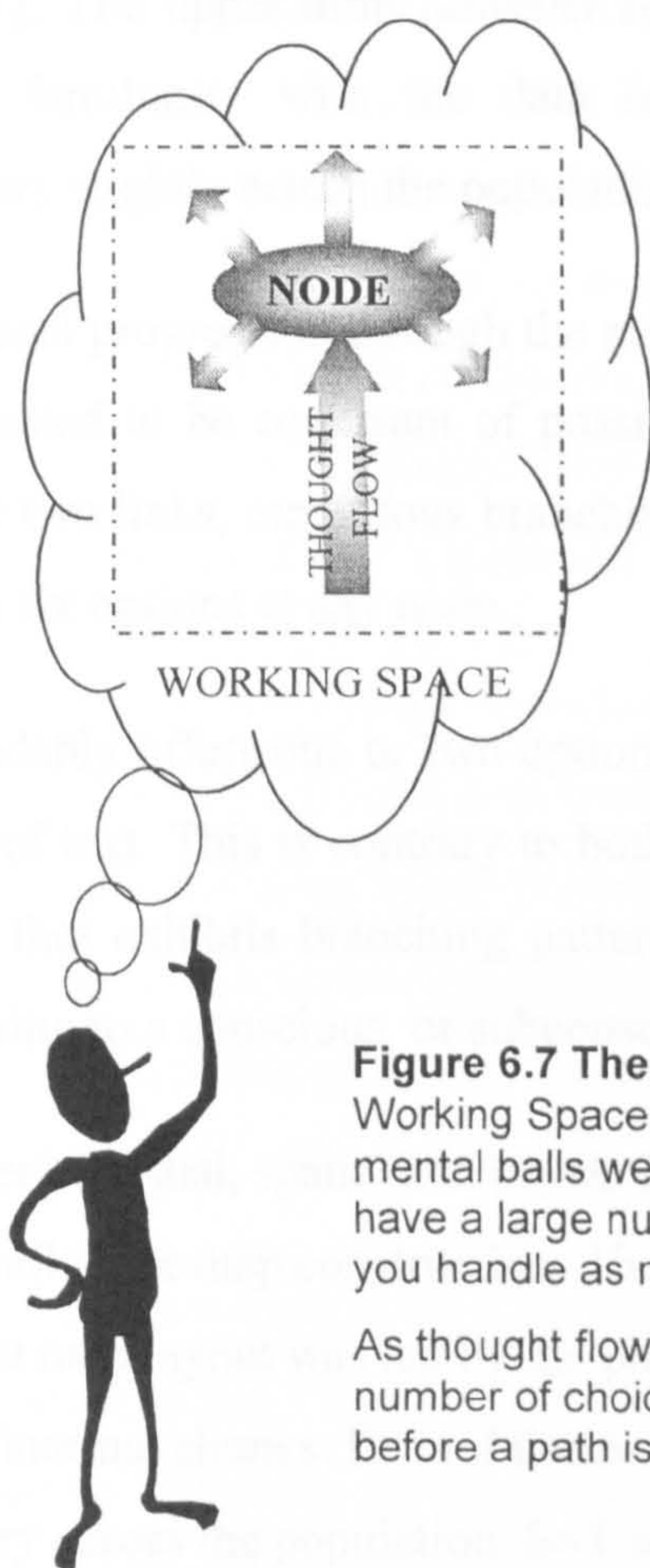
Regrettably, I could find no consistent pattern in the way the forms were used, so 'soft' or not there was no data to analyse. There were some minor problems with a few of the forms used for Scenarios 8 and 9, but I had abandoned hope of receiving useful information from the pink sheet long before. The most common occurrence was for the pink sheet to look just like the yellow sheet, both sheets torn off when the map was completed. I was disappointed that I would gain no insight from these intended two stage efforts, but more vexed that the students had wasted an excellent opportunity. I did receive some consolation, twice during data collection I received a note saying, *"I like the idea of knowing what I had trouble remembering (no notes), so I use different coloured pens. I guess that doesn't help much on your forms, I keep forgetting to tear the pink sheet off – sorry."* The same sentiment was expressed by a third student during a personal interview at the end of the year. They were right in that it provided me with no useful data, but it was nice to know that at least a few students got the most from their effort.

### 6.2.2 Map Density and Branching Patterns

In this section I want to consider the form of the maps, not aesthetically but functionally. A concept map is a two dimensional representation of the creator's cognitive network. In the mind, long-term memory is virtually limitless but our access to it, the working space, is finite. In the earlier chapters I discussed the



possible processes at work and the limitations of this space. If a concept map were to take full advantage of these attributes, it would be constructed without wasting an opportunity to insert data.



**Figure 6.7 The flow of thought**

Working Space may be seen as the number of mental balls we can juggle at the same time. If you have a large number of balls to juggle, why wouldn't you handle as many as possible at one time?

As thought flows from a previous node to the next, a number of choices must be evaluated simultaneously before a path is chosen.

The capacity of this finite working space (Fig. 6.7) should establish the upper limit on the number of branches that can be conscientiously evaluated at one time. I do not deny that there are still very serious questions as to whether we can think about more than one thing at a time. The 'working space' is the number of options that we can hold in mind and instantaneously switch from one to another in order to evaluate them. If optimal use of mental capacity is applied, then the maps should be constructed so that each node offers a number of choices approaching but not exceeding the capacity.

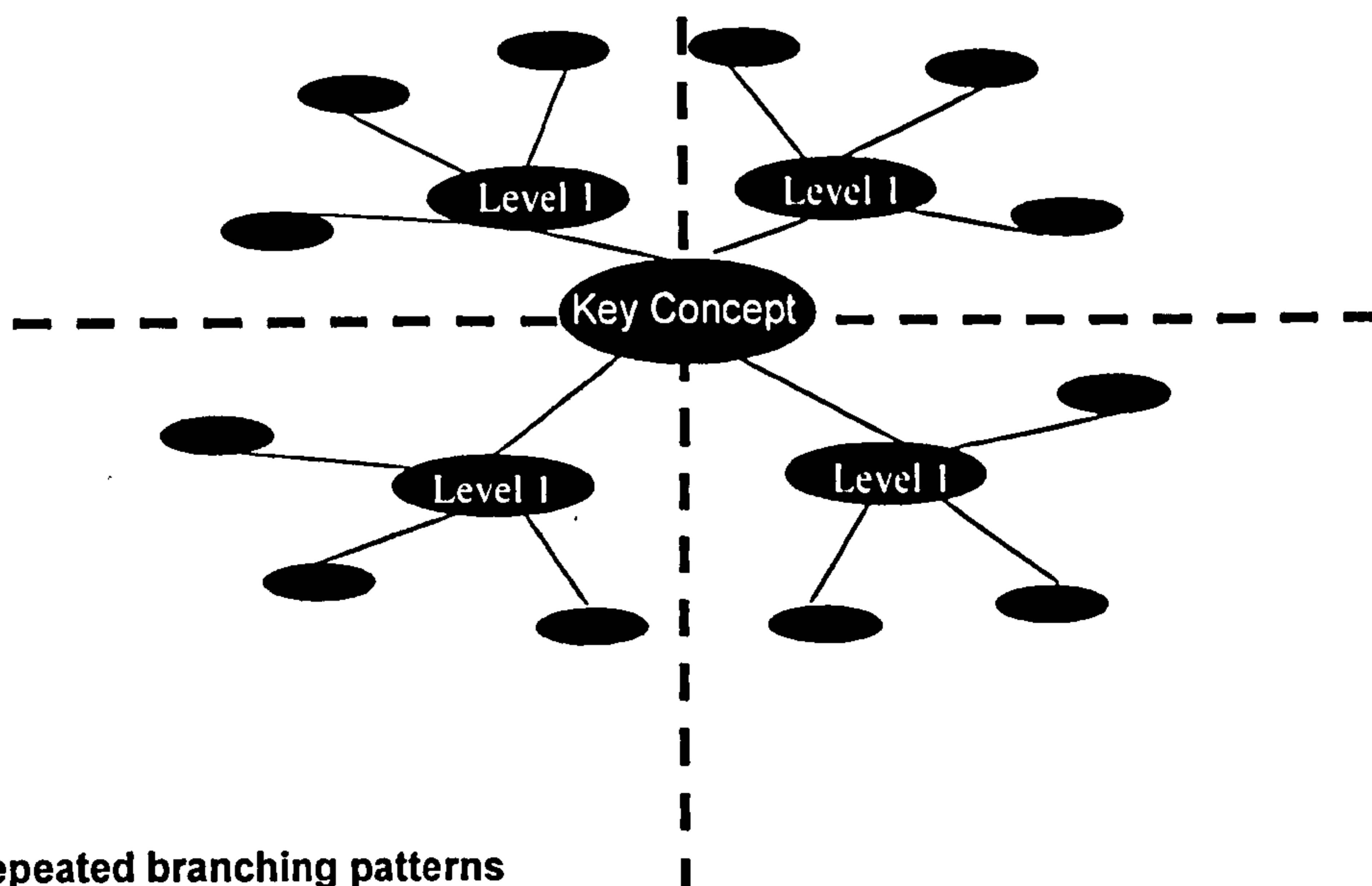


Before I proceed with my findings I would like to clarify exactly what I expected. The notion of optimal use is a theoretical construct that would apply only if the subject of the map were ignored. I did not expect the students to ignore the subject they were mapping. The upper limit however is not subject dependent, it will vary with a students' familiarity with the data being mapped and, irrespective of familiarity, will vary slightly across the population.

I anticipated a logical progression through the map with each node providing three or four options. I wanted to be cognisant of possible negative constructions, such as; nodes with one or two links, repetitious branching patterns, or a consistent tendency to offer more than six options at any node.

A map that dependably offers one or two options at each node is perilously close to the linear pattern of text. This is contrary to both the theory and practice of concept mapping. A map that exhibits branching patterns that are repeated throughout the map may be adhering to a conscious, or subconscious, formula (Fig.6.8).

There are a number of visual, spatial and psychological factors that alone or collectively may influence map construction. These are hypothetical concerns that would indicate that map layout was led by the physical structure of the map or a consistent size of internal chunks. Even if these concerns were warranted, I would expect them to vary across the population. So I was not looking for one pattern but any consistent pattern exhibited by an individual.



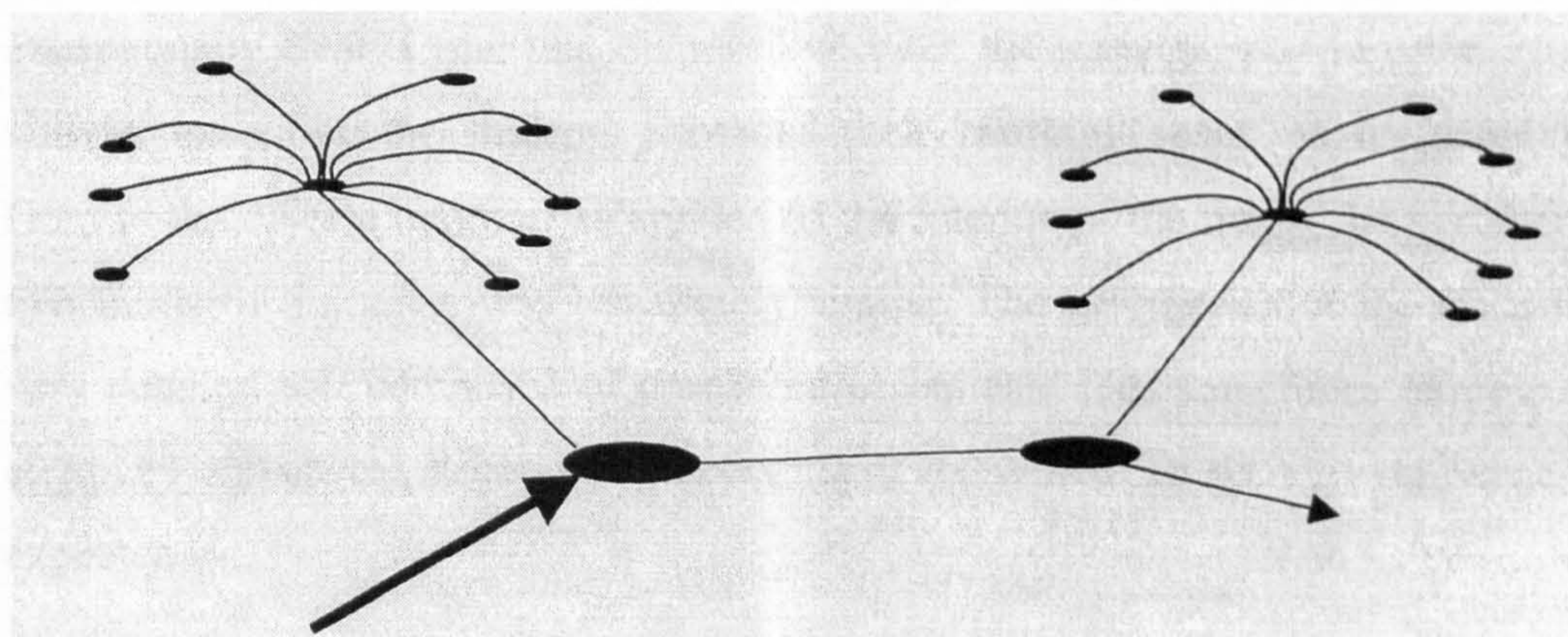
**Figure 6.8 Repeated branching patterns**  
 A branching pattern repeated four times, the key concept linked to four level 1 nodes and each of these linked to three level 2 nodes.



A map where nodes consistently offer six or more options would be expected to exceed the mental 'working space' of the students. Concept maps are intended as a short-hand reminder of the mental steps taken in evaluating a key concept. They are not intended as an excuse to write down everything you know but to allow you to see the larger picture. They should enhance understanding by indicating how seemingly distant nodes (thoughts) can influence one another. If the choices offered at a single node exceed the capacity of the 'working space' then the steps taken cannot be mentally navigated without the artificial assistance of the map. It is certainly possible for an individual to construct a concept map with these characteristics if it is a comprehensive reflection rather than a reminder of the information pathways.

I found a few instances where maps branched only a few times from the 'key concept' to level 1 and even from level 1 to level 2. As I have mentioned, this type of construction is more similar to the linear pattern of text than it is the interconnected chunking and linking characteristic of concept mapping. These maps did not continue this linear pattern throughout. As the maps proceeded to level 3 and beyond the branching pattern would shift to a starburst or spider design (Fig. 6.9).

If anything these maps went from having fewer branches than expected to more branches than expected. While I was able to find students who had a partiality for the spider design it was not utilised in the same manner in all of their maps. If one student repeated this type of mapping twice it was noted but two out of eight or nine hardly constitutes a pattern.



**Figure 6.9 Spider design**

Map construction featuring a starburst or spider design.



Looking for repeated branching patterns among the bulk of the collected maps that exhibited nodes that offered three, four or five options seems an insurmountable task. It was not. In all three cases; too few branches, repeated patterns, too many branches, I was looking for an individual student with a predilection for a particular layout. Therefore I was only examining eight to ten maps at a time. I was able to distinguish characteristics of an individual; level 1 nodes enclosed in boxes, level 2 nodes underlined, bulleted lists around the periphery. These were primarily aesthetic attributes not consistent branching patterns. The aesthetic style of the student persisted but the branching patterns did not. Without exception the maps did not indicate a formalistic construction. I could only surmise that the scenario being mapped dictated the branching patterns exhibited by an individual, as it should.

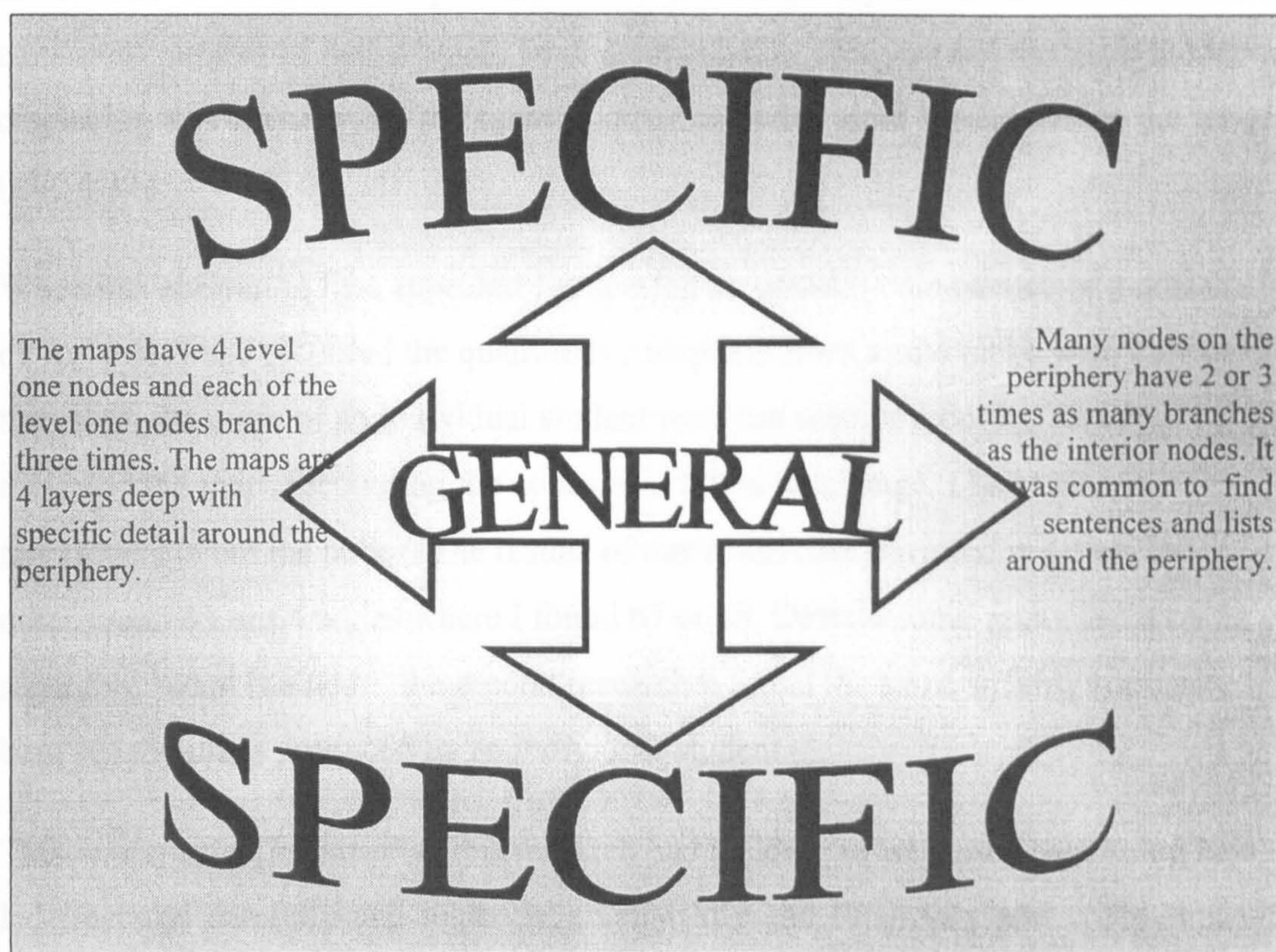
Scrutinising maps for violations of a student's 'working space' was straightforward. While I cannot place an exact figure on the number of branches necessary to exceed the capacity, seven or eight branches emanating from a single node crosses the boundary of most. As I have mentioned exceeding the capacity is a consequence of using the map to double or triple the 'working space'. This is not an unusual or incorrect application of concept maps but it is contrary to the particular process I tried to convey to the students. The concept mapping process utilised in this research was to assist in the initial placement of new information. The map was constructed immediately following the information gathering and these new pieces were utilised to understand the scenario. It was anticipated that the students would take small steps while condensing this newly acquired information to form concepts. I found that about two thirds of the maps exceeded the 'working space'. In hindsight, which is exceptionally clear, I find that the researcher not the subjects, was in error. Almost without exception the students exceeded their 'working space' in the same way. Despite the diverse approaches applied to the interior of the maps, the periphery of two thirds of the maps was remarkably similar. The peripheries of the maps were very detailed and composed of numbered or bulleted lists sometimes expressed in complete sentences. What was happening that seemed so contrary to what was expected?

I had given the students very general instructions and had further stipulated that they apply them in their own way. This was done for two reasons; the idiosyncratic nature



of learning is preserved by allowing individuals to pursue their own paths and because I wanted them to have enough freedom to answer questions which I did not have the foresight to ask. The interiors of the maps were composed of concept nodes where significant amounts of knowledge (most old, some new) were condensed and encapsulated. The exterior portions of the maps contained the bulk of the newly covered material. It was this detail the students were trying to commit to memory. Even if they could have condensed the list to a word or two they chose to use their time and their map to cover the detail again. Therefore two thirds of my collected samples displayed a concept map interior and a concept formation exterior. I suspect that if more time had elapsed between information gathering and concept mapping less detail would have been expressed and the maps would have been more uniform. However my primary goal was to help the students learn and in retrospect I would not change the process, just my expectations.

From the analysis of 546 maps I have compiled a description of the average map (Fig. 6.10).



**Figure 6.10 A typical map**  
The characteristics of an average map.



### 6.2.2.1 The Unexpected

I had examined the maps for an indication that their construction was led by anything other than a thoughtful assimilation of the data. I was pleased to find none, but I did find a pattern. It was surprising that the number of nodes did not fluctuate with the complexity of the scenario being mapped. For it not to fluctuate characteristically across the population could perhaps be explained by the idiosyncratic nature of the task. But I was totally unprepared for the pattern exhibited by some individuals. For approximately 25% of the subjects I found a strong tendency for the maps of an individual to contain the same number of nodes, regardless of the scenario being mapped.

What is a node? I defined a node as a single thought whether expressed as a word or a sentence. So despite finding no pattern in the precise layout of the maps they contained the same number of thoughts. Across the test subjects, the number of nodes ranged from around 20 to more than 140, the average was approximately 65 (Appendices F & G). If we were talking about a few students with maps containing fewer than 40 nodes and especially if any pattern in layout could be discerned, a consistent number of nodes would be understandable. This was not the case. Students displaying a propensity for the same number of nodes were spread across the range (Fig. 6.11).

When this aberration first appeared I suspected an unusual coincidence or a mistake on my part. I had recorded the quantitative map attributes as the maps were collected; therefore, the maps of an individual student were not seen or recorded together. I reviewed the maps recounting the nodes, and found no change. I had two other researchers count the nodes. The results of one researcher mirrored my own, the other found 63 or 64 nodes where I found 67 or 68. Despite some minor differences regarding 'what is a node' the second researcher found the same striking similarity between the maps produced by an individual student.

This was not the first surprise this research had yielded, so what was happening here? I deliberated carefully and logically, then wildly and illogically and could find no explanation. The only thought that came to mind was that it was some multiple of the individuals 'working space'. I found it impossible to believe that a double digit



multiple of a quantity, that had not revealed itself on an individual level, could be so precise.

	Student 210	Student 213	Student 234	Student 274	Student 279
Number of Nodes	47	68	45	110	59
	44	67	45	114	58
	46	71	46	106	58
	47	72	45	114	59
	46	69	43	106	61
	-	68	44	108	60
	44	70	46	102	59
	45	-	44	106	58

**Fig. 6.11 Student maps compared**

The number of nodes (thoughts) contained in the maps of five students, excerpted from Appendix G.

I had one opportunity to shed some light on this perplexing problem, by asking the students during interviews. At the end of the academic year I conducted a dozen interviews. I selected the students to interview and since this phenomenon appeared to be independent of all other mapping attributes, six of the interviewees exhibited this trait. The students certainly would not know how many nodes their maps contained or even what a node was. I asked ‘how did you decide how much information to put on your map?’ Two of the students opted for the obvious, “*I stopped when I had covered the topic*”. The remaining four interviewees were consistent in their responses, “*I knew I couldn’t learn everything, so I tried to be realistic and took on only what I thought I could remember*”. I applauded the candour of the students, but I can offer no further explanation.

### 6.2.3 ‘Good’ Concept Maps

Concept maps are gaining in popularity across many disciplines as a form of assessment. Therefore I wanted to compare the academic performance of students who produced ‘good’ maps to those who did not.



The collected maps were produced with the aid of notes, texts, Internet and friends, if the students so desired. Therefore, any objective analysis of the content of the maps would provide no insight into what the individual student knew. However, if maps personally created can be assessed there must be some salient qualities apparent in these maps.

By purely subjective analysis I was looking for maps that ‘flowed’. Looking for maps that exhibited a logical step-wise construction, where the flow of words and lines emanate from the centre and lead the eye and the mind through an interconnected web of thought. The natural fit between concept mapping and learning theory led me to believe that most students would produce ‘good’ maps.

On this supposition an attempt was made to place the 546 maps into one of three categories: ‘good’, undecided and ‘not good’ (Fig. 6.13) (page 117). The number of maps classified as ‘good’ increased very slowly while the undecided category was receiving the most attention. It quickly became obvious that my subjective analysis was going to yield far fewer ‘good’ maps than anticipated. Since I expected most of the students to produce ‘good’ maps it seemed clear that my assessment of the maps must be in error. I began recording a subjective impression of the map while evaluating the number of nodes, links and layers (Fig. 6.12).

<u>Student #: 201</u>	<u>Student #: 252</u>	<u>Student #: 212</u>
<p>Comments: <i>Illness, Iceberg, Incidence and Prevalence in one node, 3 branches -2 specific to general, 1 general to specific, lists and sentences on periphery</i></p>	<p>Comments: <i>Confidentiality, planar, nice branching, simplistic but logical</i></p>	<p>Comments: <i>All main issues level 1 nodes, lists, sentences, arrows, planar</i></p>

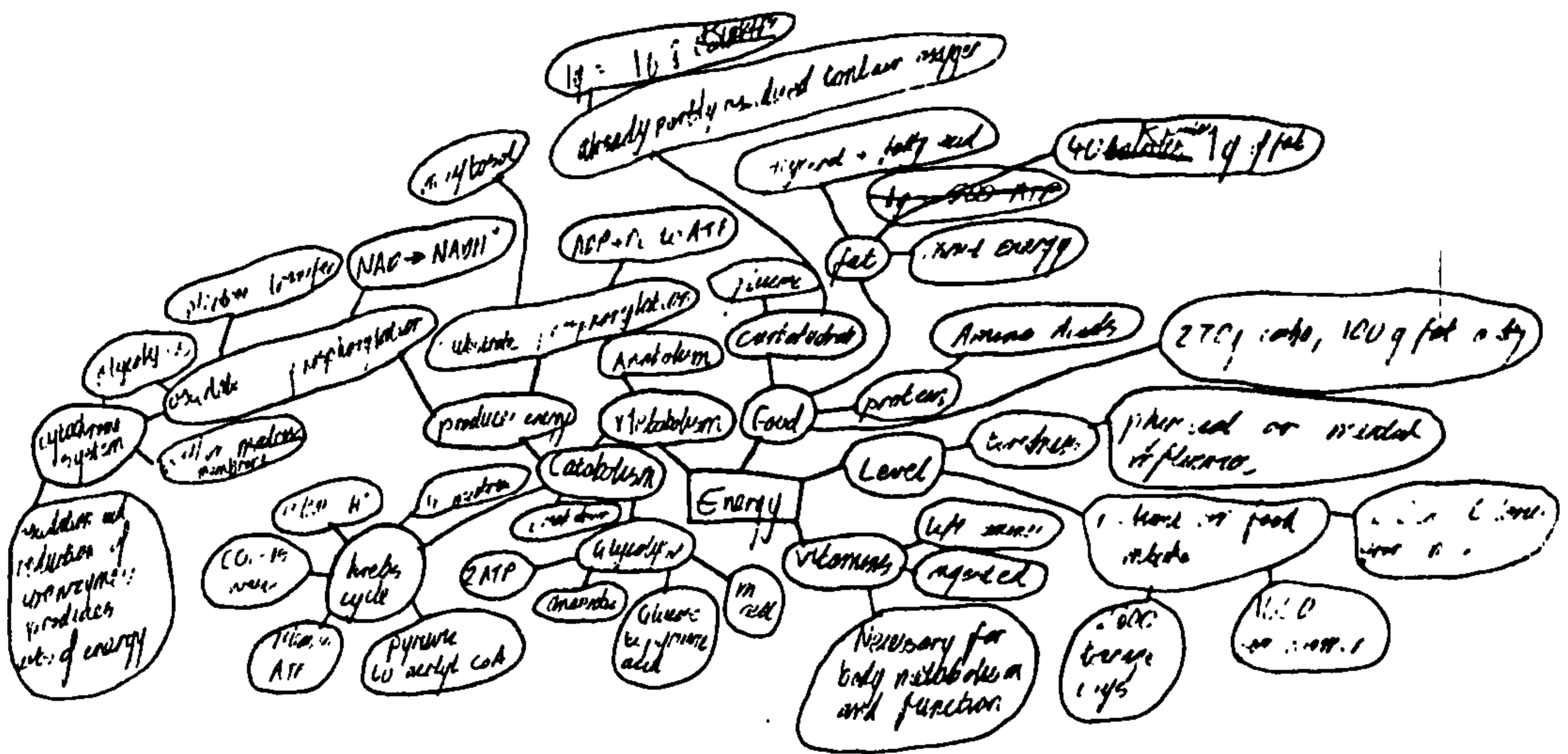
**Figure 6.12 Subjective map analysis**

Excerpts from map analysis.

As I continued the analysis I found that my most consistent comment regarding the maps was ‘planar’. Since the single word that described the kind of map I was looking for was ‘flowed’, it became readily apparent that by my subjective analysis most students were ‘not good’ at concept mapping. This realisation was worrying because I expected the contrary, but even more disturbing in that this was the tool that was to improve academic performance. If the students were ‘not good’ at concept mapping, how was it going to improve understanding and enhance performance?



A



B

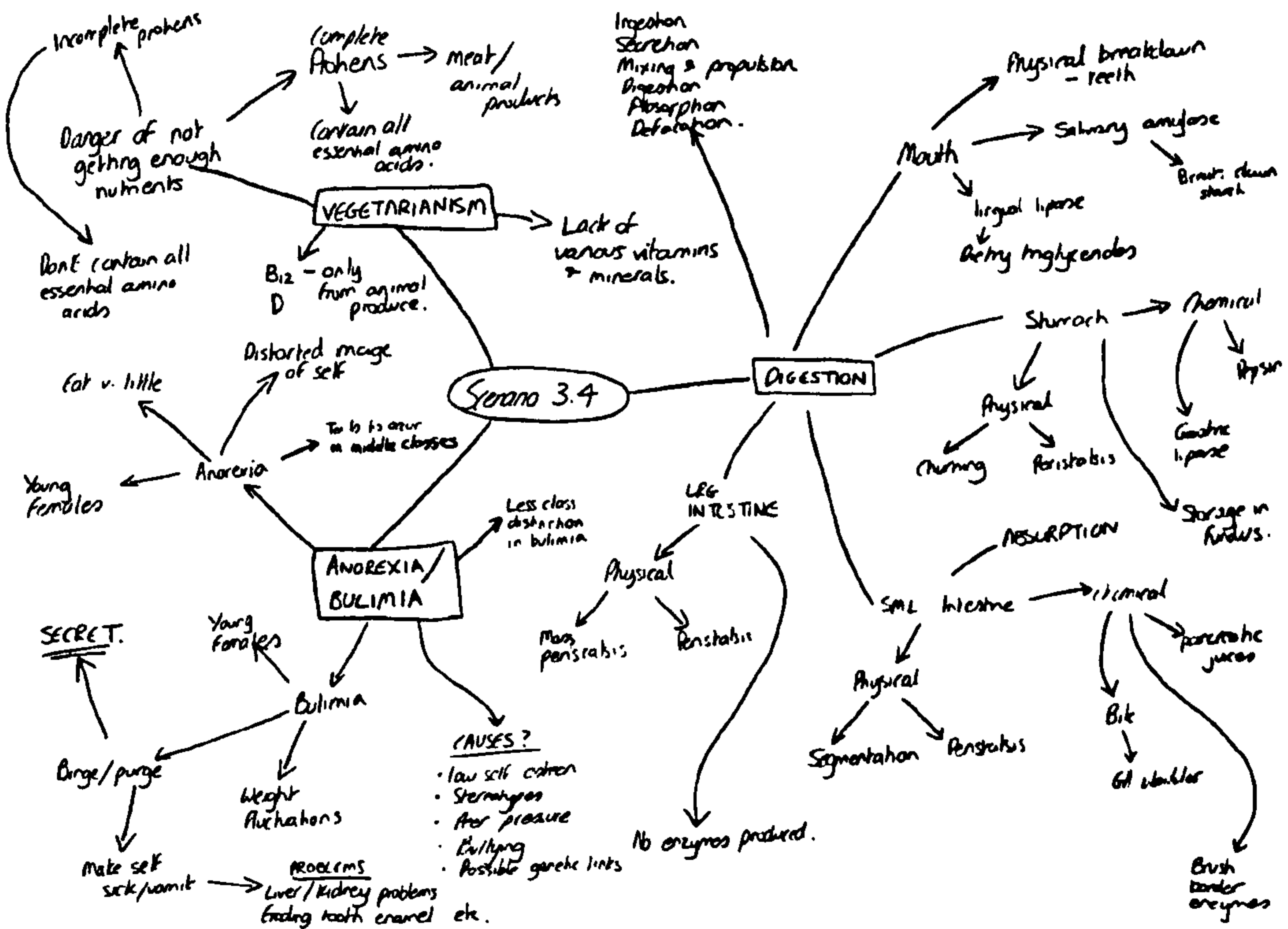


Figure 6.13 Subjective comparison  
Maps were divided into two classifications, 'not good' (A) and 'good' (B).



I began the recording of map features during data collection. By the time I had collected the maps from the first three scenarios, my concern for the students ability to construct a concept map and to gain from the experience was deeply entrenched. In general, those maps classified as 'good' were produced by the same students and they constituted only about 20% of the test subjects. That meant over 75% of the subjects were 'not good' at concept mapping. It is true that I had divided the remainder of the maps into two classifications, 'undecided' and 'not good'. But this was primarily out of frustration, none of the maps classified as 'undecided' would be changed to 'good'. I did restrict the 'not good' classification by including only maps that lacked detail and therefore tended to have fewer nodes. This division meant that the two groups, undecided/not good, were approximately the same size and each was about twice the size of the 'good' group.



**Figure 6.14 A 'not good' map**  
A map classified as 'not good', simplistic, planar, no flow.

At the end of data collection I grudgingly placed the students in their final category, 14 who produced 'good' maps and 21 who were 'not good' at concept mapping. As I have mentioned I was deeply concerned that so few of the students were going to gain from the experience. I stared at one of the maps in the 'not good' category (Fig.



6.14), no flow, no layering; even with a labelled 'key concept' I was barely able to follow the lines coming from it. How could this student have gained from the experience and further, why had the student continued for the duration of the trial? I had to ask. During interviews at the end of the year I did.

Researcher: Do you think concept mapping helped you to learn and understand?

Student: *'Yes, I think so. It was a good way to summarise my notes.'*

Researcher (placing one of their maps on the table): How did this help?

Student (pointing at the map): *'The links between ideas made it easier to remember. The different layers let me see how the pieces fit together.'*

I had told the students, when introducing this research, that these were their maps and they should utilise them in whatever way they found helpful. I asked them not to compare their map to anyone else's and that the strength of their map was what it meant to them not what someone else saw in it.

It seems I was the one not listening. The links between concepts, the flow of information, the subtle influence of seemingly distant nodes, all of these things that I had tried so desperately and unsuccessfully to find in the map, were readily apparent to the student who had created it. Even though this only confirmed my initial suspicions, I was surprised and relieved.

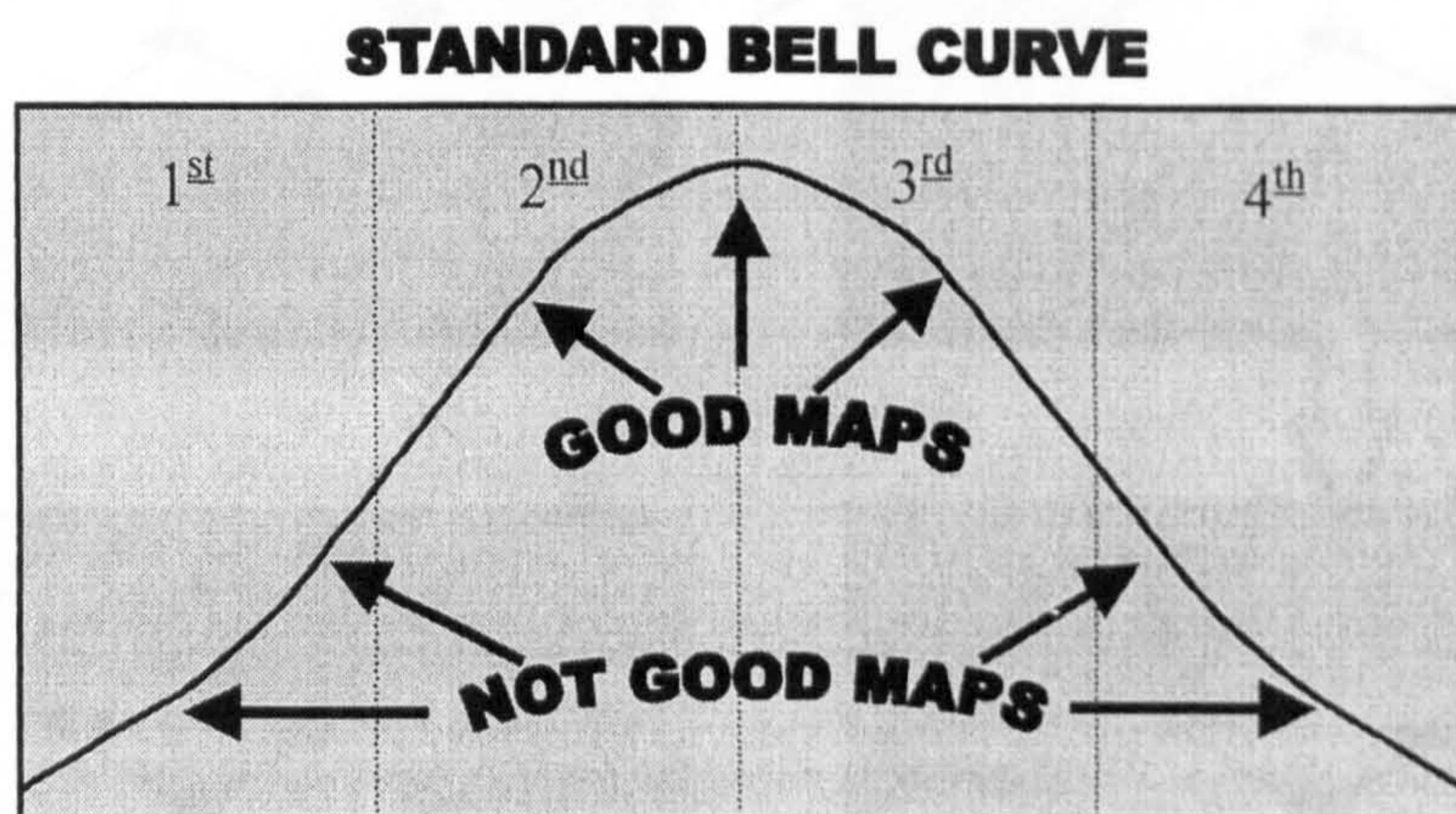
I was relieved because this meant that the majority of the class that I had deemed 'not good' at concept mapping may have received the benefits from the maps that I had hoped. Whether the process would improve academic performance would not be known until I could look at final exam scores. Despite my vehement defence of the idiosyncratic nature of the process, I was surprised. I had anticipated this result but honestly felt I could tell the difference between a 'good' and 'not good' map. I thought that doing so would rely on a number of subjective analyses therefore negating their use as a reliable form of assessment, but I thought I could do it. I was wrong.

I was about to be surprised again. I had just established that my analysis of the maps was not very accurate. Nevertheless I wanted to see how the two groups, 'good'/'not good', fared on the final exam. After checking the exam scores, I have indicated the



trends exhibited by the two groups of students on a hypothetical bell curve divided into quartiles (Fig. 6.15). This is soft data categorised as I have indicated, as such statistical analysis is not relevant.

Despite the recent revelations of the maps classified as 'not good', I expected the students who were 'good' at concept mapping to score above average on the final exam. They did not. Instead of being spread through the 3<sup>rd</sup> and 4<sup>th</sup> quartile they were perfectly average and equally distributed in the 2<sup>nd</sup> and 3<sup>rd</sup>. This result was not exactly predicted but this is not the surprise.



**Figure 6.15 A normal distribution**

A hypothetical bell curve that has long been associated with the academic performance of a population. The arrows represent trends based on a subjective analysis of the student prepared maps.

It had been literally 'pointed out' to me that I was not capable of evaluating the maps labelled 'not good'. It was anticipated that these students, incorrectly labelled, would be randomly spread throughout the curve. I was surprised to find them strongly associated with both ends but not the middle of the curve. This was adding insult to injury for the poor researcher who had missed it so badly.

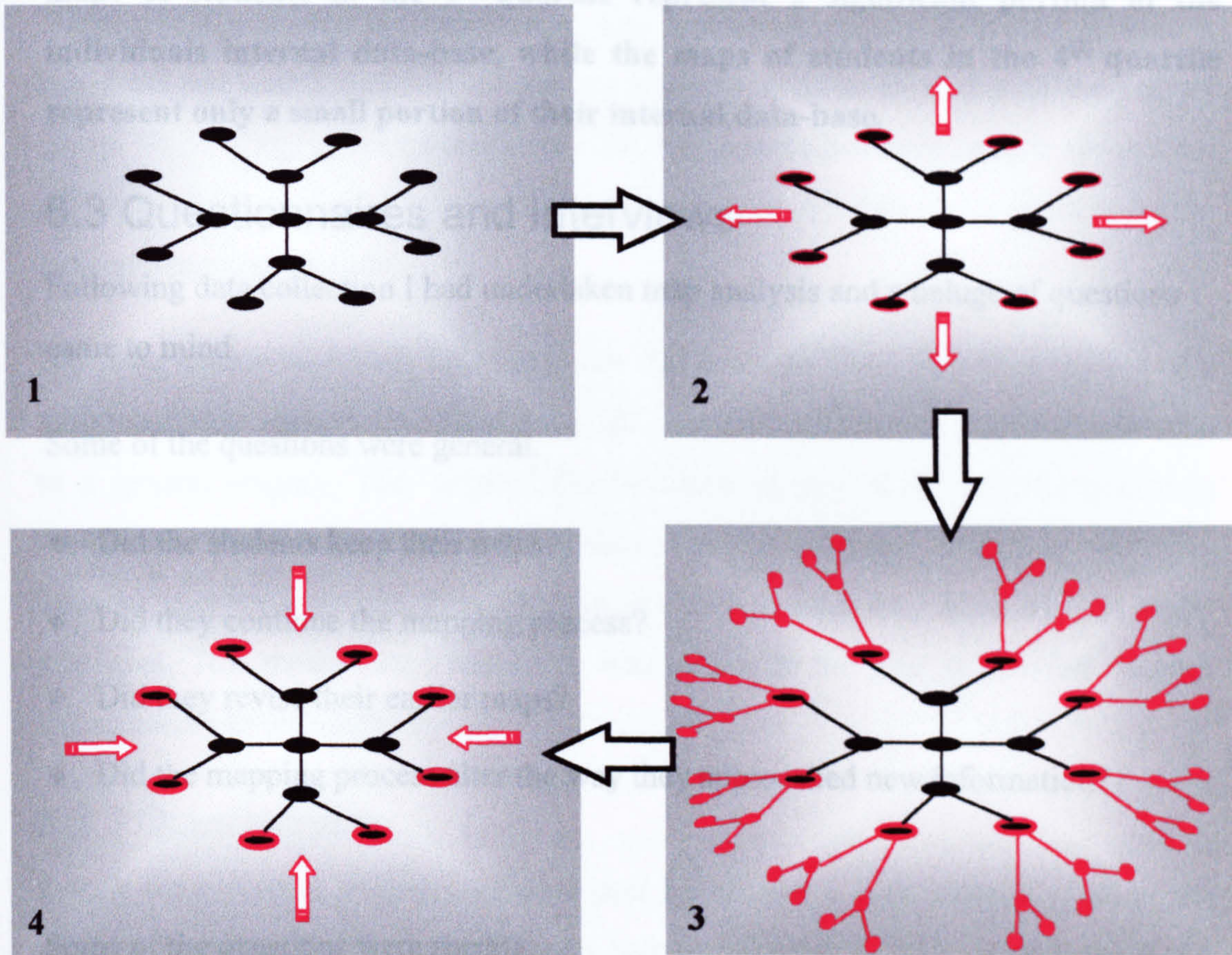
I was prepared to accept that I was seeing ghosts where there were none. But the scores exhibited by the two groups were not randomly distributed. Though not without exception, the trends indicated on the graph were remarkably strong. While my labels were obviously erroneous it was apparent that there was some delineation between the two groups.

I found it!



It was the number of nodes.

During the initial evaluation I had become frustrated that so many of the students were 'not good' at concept mapping. I had reduced the size of this classification by restricting it to maps that lacked detail. Consequently maps labelled 'not good' tended to have fewer nodes than the maps in the 'good' or undecided category.



**Fig. 6.16 The choreography of learning (chunking of LTM)**

The scenario activates the students' previous knowledge (1). As the discussion (brainstorming) continues, questions are generated. This process coupled with the desire or need to know more, primes the appropriate nodes for expansion (2). The student answers the questions expanding their data network (3). This expansion is composed of specific facts and detail. As the detail becomes assimilated and networked it no longer requires nodes of its own and now rests comfortably incorporated back into the node from which it branched (4).

Let us now dispense with my obviously erroneous label of 'not good' and concentrate on two different but related questions. How could maps produced by students who performed well above average on the final exam be indistinguishable from the maps produced by those who performed well below average, and why would the maps of very good students contain less information and detail than the maps of average students?



A possible answer to both of the questions is offered in Fig. 6.16. It would make a pretty narrative to say that the number of nodes increased through the 1<sup>st</sup> and 2<sup>nd</sup> quartiles and decreased through the 3<sup>rd</sup> and 4<sup>th</sup> quartiles, (Fig. 6.15). A pretty narrative but not supported by the collected data. What is supported by the data is that the maps of students in the 1<sup>st</sup> and 4<sup>th</sup> quartile had significantly fewer nodes than the maps of students in the 2<sup>nd</sup> and 3<sup>rd</sup> quartile. **The obvious conclusion is that the maps of students in the 1<sup>st</sup> quartile represent a significant portion of the individuals internal data-base, while the maps of students in the 4<sup>th</sup> quartile represent only a small portion of their internal data-base.**

### 6.3 Questionnaires and Interviews

Following data collection I had undertaken map analysis and a deluge of questions came to mind.

Some of the questions were general.

- ◆ Did the students keep their maps?
- ◆ Did they continue the mapping process?
- ◆ Did they revise their earlier maps?
- ◆ Did the mapping process alter the way they approached new information?

Some of the questions were specific.

- ◆ Do you think concept mapping helped you to learn and understand?
- ◆ How did it help?
- ◆ How did you decide the amount of information to put in the map?

In addition to these questions for the test subjects, I had a number of curiosities about the study habits of the remaining students in Group C.

- ◆ Do you use Mind Maps?
- ◆ Does your normal study routine involve trying to understand the scenario?
- ◆ Do you just study the answers to your questions?



None of these questions was particularly difficult or time consuming to answer. The difficulty was how and when to ask. I had no direct contact with the students during data collection. This lack of contact was by design and for two reasons.

The reliability of the collected data would have been compromised if I had been constantly visible to the students. I was concerned that my presence would have been a reminder that they were performing a task rather than having the process become incorporated into their normal routine. The second reason was indirectly related in that I did not want the routine of the test subjects to differ from that of the control group. None of my previous meetings with the students had been outside the normal schedule of the medical school and I wanted the only variable in this work to be the concept mapping process.

The clear choice was a brief questionnaire that could be administered at the end of a scheduled PBL session. Questionnaires can be quite informative by indicating trends to a general enquiry. This negated the inclusion of any of the specific questions mentioned. The timing of the questionnaire was also pertinent in that, of particular interest, was the potential long-term impact this process may have had on study strategies. This meant that I wanted to wait as late in the year as possible without losing access to the students.

### 6.3.1 Questionnaire

During the last week of their academic year I presented a questionnaire to all of the students in group C. The students who had participated in this research answered both sets of questions. Those that had not participated answered only the questions on study skills.

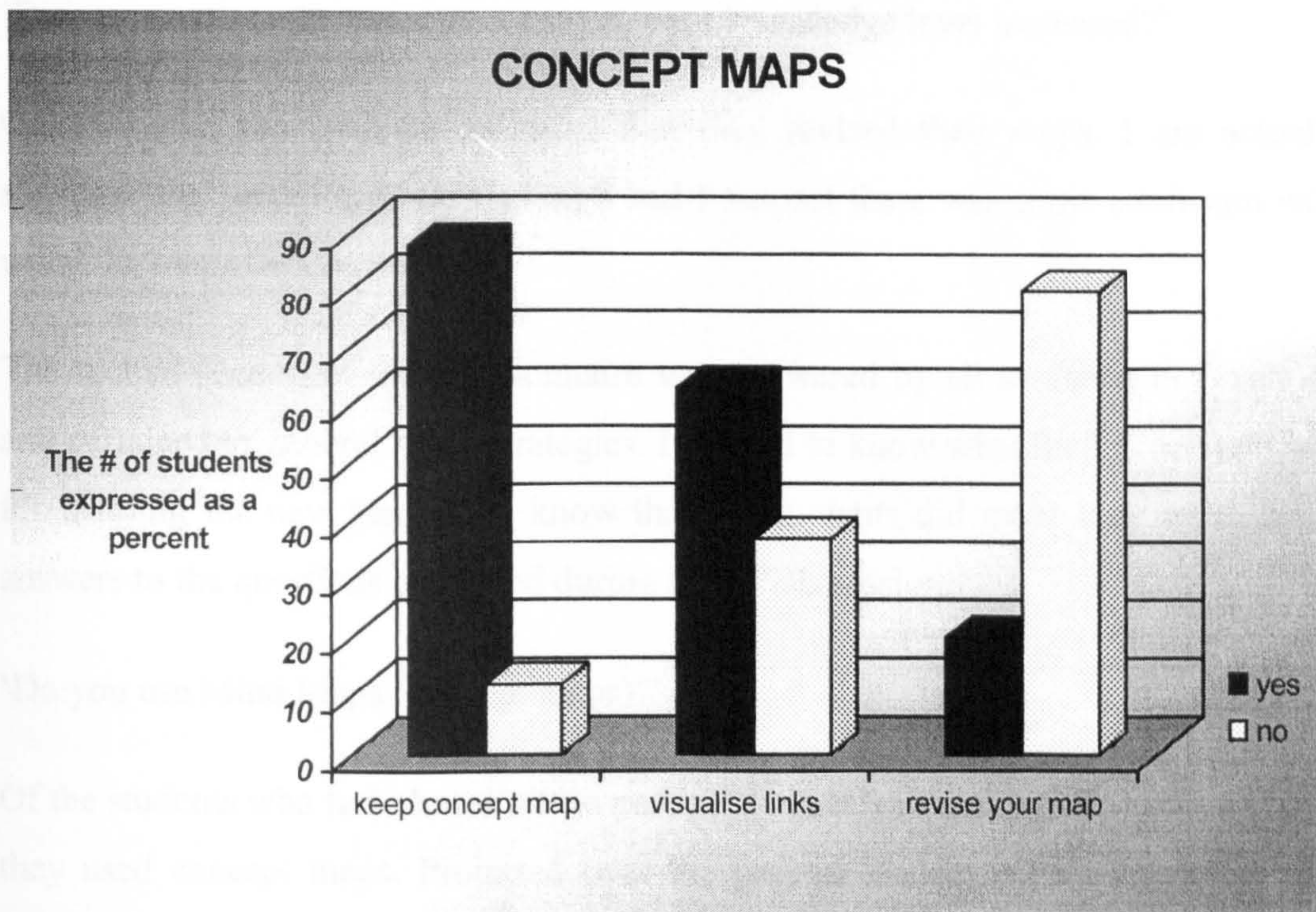
This research had yielded a surprise or two, if not consternation, so at this point I wanted to take nothing for granted. In the section on Concept Mapping my first question was

‘Did you keep your concept map for later study or review?’

I was pleased to find that 88% of the students had kept their maps (Fig. 6.17). The questionnaires were anonymous and I suspect that some of those who had ticked the no box were students that had chosen not to participate in the process. In the



comment section the most prevalent response was the use of the maps to review for the final exam.



**Figure 6.17 Questionnaire, concept mapping**  
Results of the questionnaire on concept mapping.

The second question was a bit more optimistic. As the students practised the mapping process it was my desire that they would begin to view new material in the light of their previous efforts. I did not expect them to visualise a previous map and how the new information fitted into it. Learning by association, the chunking and linking of information, these are subconscious facts of cognition. It was my hope that by making the students aware of these facts that they would consciously use them to their advantage. When presented with new information the students should think of its possible applications, potential links.

‘Did you begin to visualise links between new information and previous knowledge?’

This desired outcome was expressed by 63% of the students.

This questionnaire represented my first contact with the students after data collection. My concerns regarding the usefulness of the mapping process have already been expressed. In retrospect I would never have asked the following



question, but at the time I was concerned that only a few of the students appeared to be getting anything out of their mapping effort.

‘Did you continue to revise your map as your knowledge level increased?’

Only 20% of the students indicated that they revised their maps. I am actually surprised the percentage was that high and I suspect there was some confusion with using the maps for revision.

The second section of the questionnaire was answered by all students, in Group C, and pertained to general study strategies. I wanted to know what their procedure was for learning the new material. I know that the students did more than write down answers to the questions generated during their PBL session.

‘Do you use Mind Maps (concept maps)?’

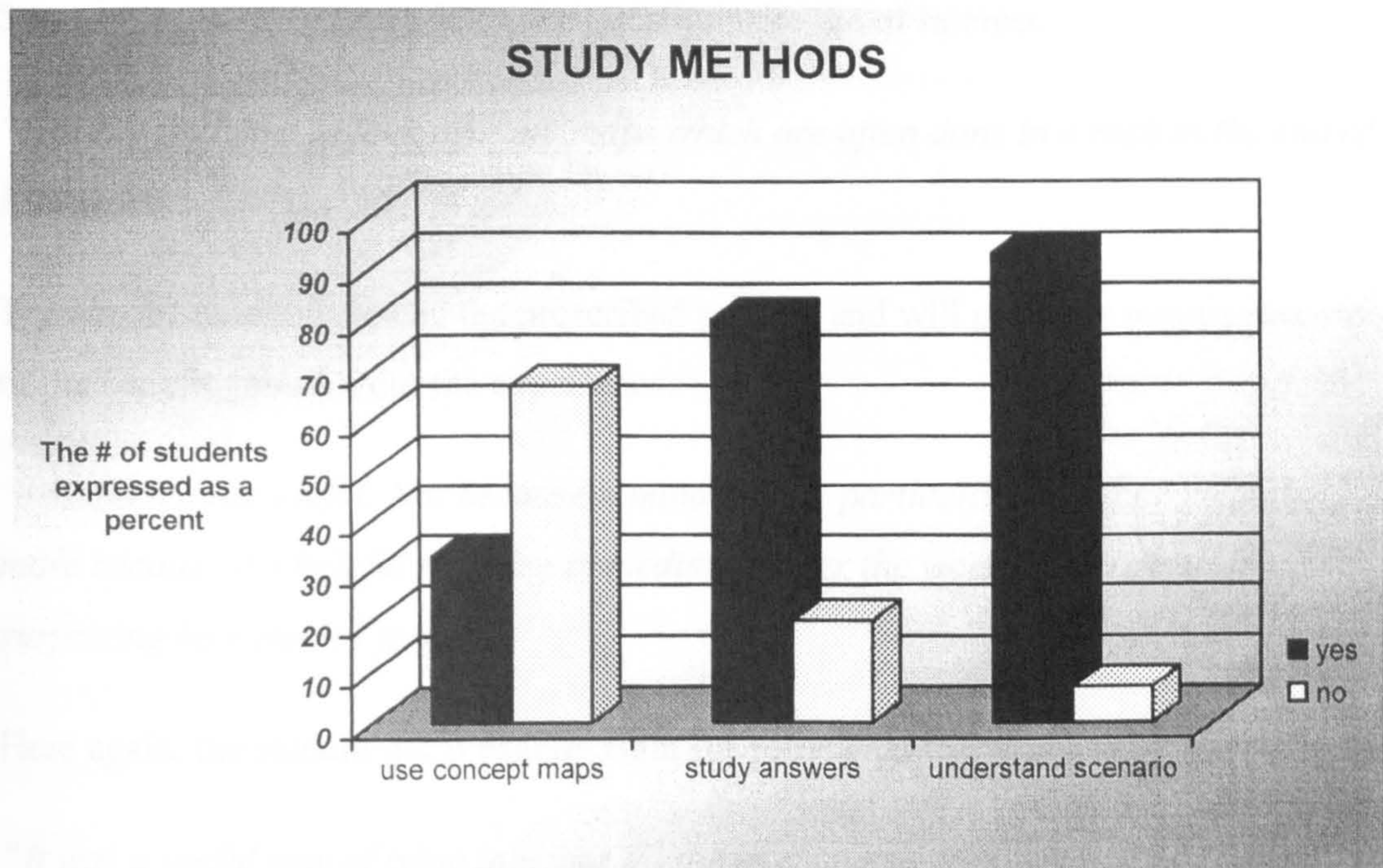
Of the students who had chosen not to participate in this research, 33% indicated that they used concept maps. Projected over the general student population I find this quite a high number. During my pre-data collection lectures I had pointed out that process used by the Scribes during the ‘brainstorming’ session was a concept map of sorts. I think that this information coupled with the students who had prepared a few maps had artificially inflated this number.

I am afraid that I skewed the response to the next question. I had prefaced this section with the statement ‘I know your study extends beyond writing down the answers to the questions generated in the previous PBL session’.

‘Do you study and reflect on the answers you have found?’

I suspected then and know now that this is in fact the strategy used by almost all of the students. By insinuating that this was only a starting point not an endpoint I led some students away from their preferred response. The responses indicated that this was the strategy used by 80% of the students, about 19% lower than the actual number (all of the students use this strategy).





**Figure 6.18 Questionnaire, study skills**  
Results of the questionnaire on study skills.

The final question was an area of great interest but the query was not worded properly.

‘Do you try to understand the scenario in light of your new information?’

This was exactly the question I wanted answered, but in this case there were far too many distracters for the students. The scenario had initiated the process and from it the questions were generated. Some of the questions referred directly to the scenario and during the debriefing some facilitators refer to the scenario regarding the depth of understanding desired. For these reasons the 93% affirmative response seems a bit low. What I actually wanted to know is if the students tried to understand the entire scenario, not individual pieces of it, in the light of their new-found knowledge. If this had been the question answered by all of the students the percentages may well have been reversed.

In retrospect I am disappointed in this questionnaire. It was conducted before I had gained any insight into the usefulness of the process I had asked the students to use. At the time I was gravely concerned that few of the students had gained from the experience. In the light of personal interviews and the exam results that followed I would have changed the wording if not the questions entirely.



Some of the comments made on the questionnaire are of interest.

*“Hard to find time to look over my maps which are often done in a rush at the end of PBL work.”*

The above student followed the prescribed process and will probably remain unaware of the benefit gained from the experience.

*“I found it quite useful. Not because a mind-map is particularly good or helpful, more because it’s helpful to revise immediately after the work’s been done. It’s surprising how much I forget.”*

Here again, the student got it exactly right for somewhat the wrong reasons.

*“It was a useful way of tying together all the new information you had just learnt, getting it clear in your head what you had learnt and good prep for presenting back to the PBL.”*

*“Although initially tiresome, I found that completing the concept maps became a valuable way of looking at the wider picture and tying up information at the end of each PBL.”*

*“A good way of reviewing, summarising and committing to memory the main concepts from each PBL.”*

I was not only pleased with the positive nature of these responses but the implication that the process had been incorporated into their normal study routine.

### 6.3.2 Personal Interviews

When the students had completed their academic requirements for the year I contacted twelve students by e-mail and set-up interviews. These students were not chosen randomly, they were selected to answer some specific questions.

The key bit of information gained from these sessions I have mentioned earlier in this chapter. Three of the students interviewed I had deemed ‘not good’ at concept mapping. I asked the students if they thought the process had helped them learn and understand. All three of the students answered that they thought it had. I was relieved by the response but wanted to know how these maps that I could barely follow had



helped them. I placed one of their maps on the table and asked, 'how did this help'? In all cases the three students pointed out features of the map that were not visible to me. In theory I could have predicted this result, in practice I was amazed. This revelation changed so many things about my interpretation of this material. I had resisted the temptation to ask these questions midway through data collection. If I had done so, I certainly would have slept better and would have changed the questionnaire just discussed.

I presented four of the students with one of their earlier scenarios and asked them to produce a concept map. At the time I was interested in whether they could produce a map similar to the one I had on file. I wanted to know if the mapping process would help them remember the chunks and links that they had formed when studying the material. As it happens their maps were very similar to the previous ones, the map of one student was almost indistinguishable from their earlier effort. Good! No, not good. Once again I had asked the wrong question. The students had taken 15 to 45 minutes to produce their maps with no notes. This was a little longer than I had hoped. The problem, they were trying to recall their earlier map. These students had learned a great deal since they had produced their earlier map and instead of viewing the scenario in the light of this new information they tried to remember what they had done at the time. I should have presented them with a new scenario covering the same material to see how their concepts had changed.

Six of the interviewees' exhibited the strange phenomenon of producing their maps with the same number of nodes. I was and remain at a loss to explain this result. The students of course were unaware of it and I simply asked them how they decided how much information to put on their map? As previously mentioned, two of the students said they stopped when they had covered the material. They had merely rephrased my question. The other four indicated that they tried to include only as much as they could hope to remember. This is a better answer but does little to explain this unusual finding.

I asked all of the students about the PBL process. The question was met with guarded optimism, having just completed the final exam. In general they liked it, particularly the freedom it gave them. Two of the students were regretting their lack of discipline in dealing with this new found freedom. This was exam week and the students were a



bit stressed and so their comments were perfectly understandable under the circumstances.

My final question to the students was regarding a mock exam that had been scheduled earlier in the spring but had been cancelled. Four of the students were somewhat ambivalent about the cancellation. The remaining eight students were a bit concerned and complained about a lack of feedback during the year. The PBL process provides the students freedom from the pressures of multiple exams associated with traditional education. In education we have long accepted the fact that assessment drives learning. This means that the students are always preparing for an exam instead of trying to learn and understand the material. Students who are experiencing PBL for the first time are often concerned by the lack of feedback. When students are being assessed all the time they may not understand the material but they know what is expected of them. This is a common problem in PBL and mock exams are a possible solution. But mock exams are as difficult to arrange and mark as an actual assessment. An alternative to a mock exam might be to work with the students on study skills and the types of questions they should be able to answer not how to answer.

## 6.4 Exam Results

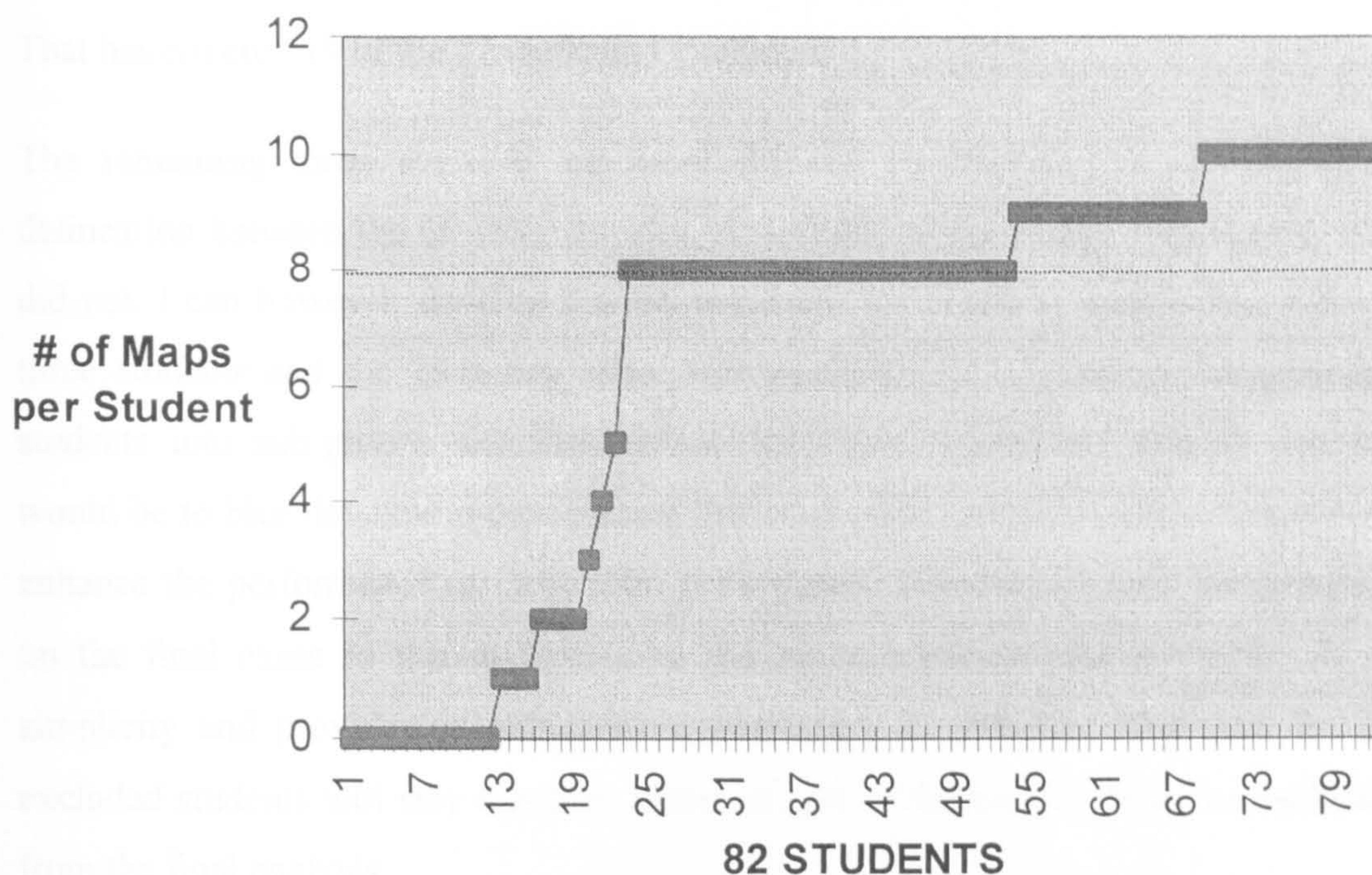
Previously in Chemistry and Biology, I had been taught that the first rule of research is 'you don't lose data' (if the procedure was correct, so is the result). But students are not chemicals in a test tube....

The purpose of this research was to enhance the performance of the students who followed the prescribed process. From Fig. 6.19 it is not difficult to determine which students took part and which did not. Of the 82 students in Group C, 60 produced at least eight of the ten maps.

The difficult question is what to do with the 22 students who chose not to participate or made a perfunctory effort. I received no maps from 12 students; from seven I collected one or two maps; the remaining students contributed three, four and five maps respectively.



## COLLECTED MAPS



**Figure 6.19 Collected concept maps per student**

The 82 students in Group C produced 546 maps; 12 students - 0 maps, 3 students - 1 map, 4 students - 2 maps, 1 student - 3 maps, 1 student - 4 maps, 1 student - 5 maps, 31 students - 8 maps, 15 students - 9 maps, 14 students - 10 maps.

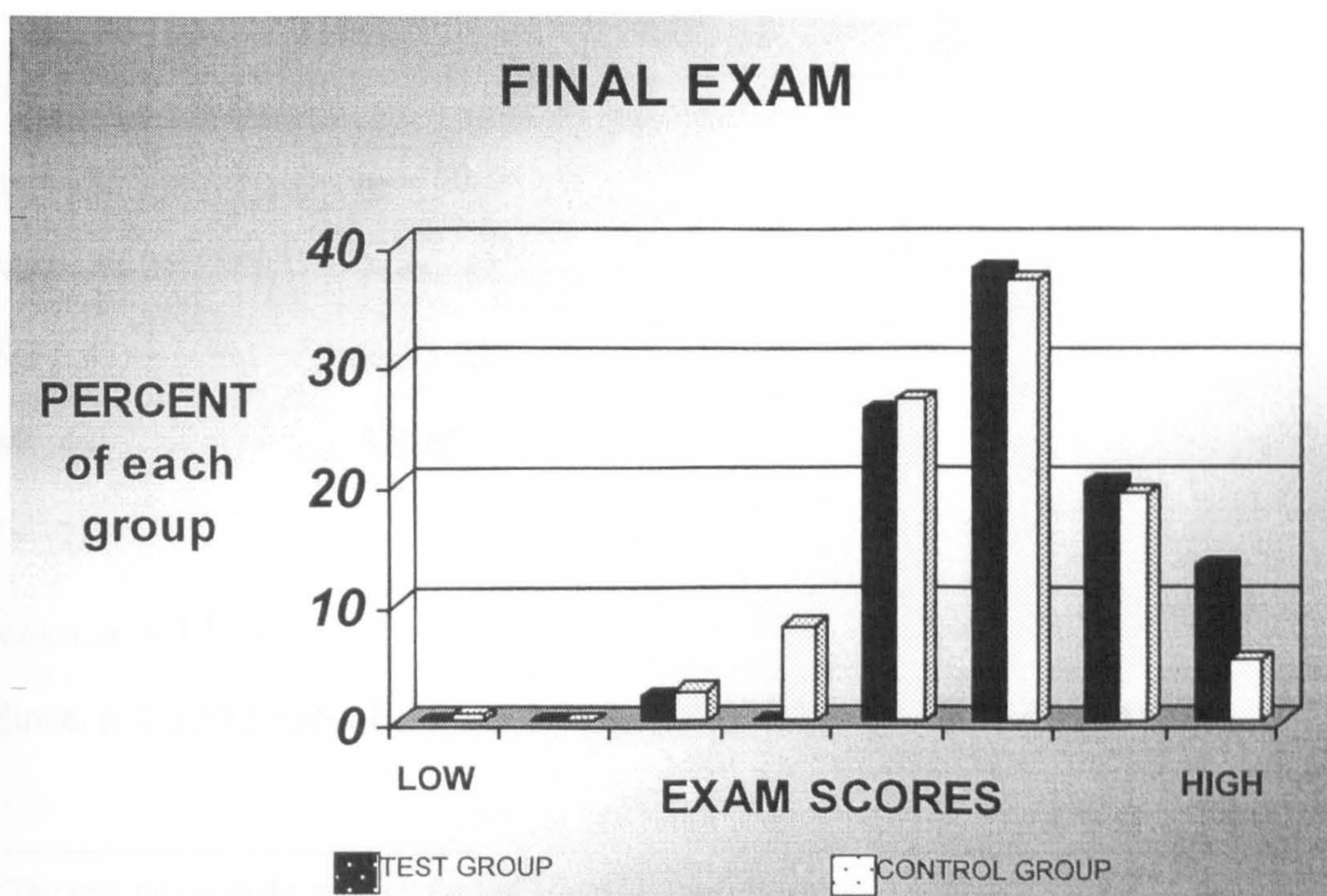
The 12 students who produced no maps are not substantially different from the students in Groups A and B (the control group). From a research perspective what we fear is to contaminate the control group with confederates or to skew the curve by a glut of a particular fragment of the population. I am quite comfortable that there is no cause for concern about group contamination. In their handouts, the Medical School suggests that the students become familiar with Mind Mapping via Buzan and as part of the small group process the students collectively produce a similar looking product during their 'brainstorming' phase. I did speak with and provide handouts for Group C, but there were no sessions scheduled outside the regular meetings of the medical school. It is my considered opinion that neither in writing or verbally did I supply the students with any incentive other than to try the process.

The only means I have to evaluate the second instance is the final exam scores and I am not comfortable starting with the answer and working backwards. As might have been suspected, over half of this group of non-participants is composed of members



of one PBL group and I have previously mentioned that I found nothing remarkable about the performance of this group in any respect. Continuing the argument I can not imagine how producing one or two maps alters the qualifications of the students. That has covered 19 of the 22 students I excluded.

The remaining three students are more difficult to allocate. There is a clear delineation between the 60 students who participated in the research and those who did not. I can however, develop a weak argument for differentiating between these three students and the 19 others who were excluded. If I break-up the excluded students into sub-groups and then subjectively place them, my deepest concern would be to blur the clear indications of this work. The goal of this research was to enhance the performance of those who participated. To compare their performance on the final exam to the students who did not use the process is elegant in its simplicity and provides as unbiased an evaluation as possible. Therefore the 22 excluded students will stay together, either as part of the control group or excluded from the final analysis.



**Figure 6.20 Exam Scores**

Compares the percentage of each group by exam scores.  
Test group (60); Control group (185)

Exam results were supplied by the medical faculty and can be seen in Appendix H.

Statistical analysis was carried out by SPSS software, version 4.



The 245 first year medical students were divided into two\* groups, the test group (60) and the control group (185).

Perhaps the most commonly employed biostatistical procedure is the comparison of two samples to infer whether differences exist between the two populations sampled. The t-statistic, 'Student's t', is a powerful measure for moderate to large sample sizes. The theoretical basis of the t-test assumes that sample data came from a normal population. The two groups, test and control, were graphed and appear to be normal distributions (Fig. 6.20). In addition tests for skew and kurtosis were performed and no significant deviation from normality was found. Fortunately, the t-test is robust, meaning that its validity is not seriously affected by moderate deviations from this underlying assumption, especially for the two-tailed test. Since we are testing, not just a difference in mean, but for an improvement throughout the distribution, a two-tailed test was done (equal variances not assumed).

$H_0: \mu_1 = \mu_2$  (there is not a statistically significant difference between the two groups)

$H_A: \mu_1 \neq \mu_2$  (there is a statistically significant difference between the two groups)

$\alpha = 0.05$

$n_1 = 185$

$n_2 = 60$

Mean 66.27

Mean 68.23

SD 5.47

SD 5.23

SE .40

SE .67

$t = -2.492$

$t_{0.05(2), 243} = 1.972$

Since,  $|t| \geq 1.972$  reject  $H_0$        $0.01 < P(|t| \geq 2.436) < 0.02$  [ $P = 0.014$ ]

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\* The two groups in the text are; the test group (60) and the control group (185). If the 22 students, excluded from Group C, are excluded from the analysis the two groups are; test group (60) and control group (163). The mean – test 68.2, control 66.7. A two-tailed t-test was performed,  $t = -1.985$ ,  $t_{0.05(2), 221} = 1.972$ . Since,  $|t| \geq 1.975$  reject  $H_0$ .



The statistical analysis indicates that the null hypothesis, stating that there is no difference between the two populations, is rejected. Therefore, we accept the alternate hypothesis, which measures the difference between the populations in either of two directions (two-tailed test). The critical value for this comparison was determined for the 5% significance level,  $\alpha = 0.05$ . Because of the subjectivity of visually analysing graphed data and the lack of reliability in tests for normality, Hsu (1938), equal variances between the populations are not assumed. The comparison of two means without assuming equal variances is known as the 'Behrens-Fisher problem', Behrens (1929), Fisher (1939). This testing process without assuming equal variances is a more vigorous measure and reduces the likelihood of a Type I error. A further indication that the two populations adhere to the Gaussian distribution is shown by the closeness of the t-statistic by either analysis, equal variances not assumed and equal variances assumed.

The statistical analysis indicates that the two groups, test and control, are significantly different. The exam scores of the test group are approximately two points higher. Based on the range of final exam scores this indicates an enhanced performance of the test group of more than 6% on the actual examination. What is more, there is an overall improvement throughout the distribution. **Students of all abilities showed improvement.**



*A great strength of the PBL process is the freedom it affords the students, the freedom to discover the answer. The answers cannot be unique; the answer to a question is specific. But the path and the pace leading to the answer may be as unique as the students themselves. The 'main issues' selected by the students during the brainstorming phase of their group process act as anchors for the new information subsequently studied. This research indicates that these anchors, once chosen, are highly resilient. As educators we may see this as an opportunity to make a lasting impression on the students. I will expand these comments in the following chapter. But if too much control is taken from the students we may be hoist by our own petard.*



*The culmination of the brainstorming session is the generation of questions. These questions will drive the learning process from this point. My analysis indicates that the style, wording or number of questions has little impact on the quantity or quality of data gathered. This finding should alleviate the concern of some administrators and staff. This finding along with a caution will be repeated in the following chapter. I am not restating this conclusion because there are further implications but to caution against trying to find any. All learning is initiated by a specific or implied question. These are first year students and the bulk of their information gathering is of the general nature. The generation of agreed upon questions is an integral part of the small group process and their specific importance will increase as the sophistication of the student moves from general to specific.*

*How can a student explain diverse scenarios with the same number of thoughts? On occasion research yields a total surprise; this was one such occasion. When this phenomenon first appeared I was completely bewildered, and so I remain. The finding here is that 20% of the students in the test group produced concept maps of different scenarios with the same number of nodes. Is this finding statistically relevant? I cannot answer that question. This finding was not being tested for and statistical relevance is not the manipulation of arbitrary data to see if it conforms within certain limits. Statistical relevance is the product of prior planning, where data collection and statistical analysis including critical points are established prior to the start. In loose terms I computed the average number of nodes for an individual and then determined a range of  $\pm 5\%$ , to see if the number of nodes on their maps fell within this range. I am at a loss to explain this unusual occurrence. Is it physiological or psychological? What I can say is that it does not appear to be linked to any of the other subjective or objective attributes I was analysing. These students; did not have more or less nodes than the other students, did not perform better or worse on the final exam, did not exhibit above average artistic ability, did not come from a particular PBL group.*

*As educators we often find ourselves pinned between the horns of theoretical constructs and the practical application of a desired process. This was the position in which I expected to find myself when subjectively categorising maps as 'good' or 'not good'. I felt that the process could not be relied upon as a practical form of*



*assessment but I never doubted my ability to distinguish between a good student and a poor one by virtue of their Concept Mapping ability. I was wrong. Concept Maps, as used in this research, are an intimate expression of internal 'chunks and links'. The idiosyncratic nature of the process yielded maps of limited value to anyone other than their creator. For anyone considering Concept Maps as a form of assessment the striking similarity of the maps produced by students at both ends of the bell curve warrants some attention.*

*Beyond the primary goal, there were a number of peripheral issues this research was designed to examine. The outcome of these secondary examinations, pertaining to Concept Mapping and Problem-Based Learning, ran the gambit from the comforting reassurance of long held beliefs to the totally unexpected.*

*The primary goal of this research was to enhance the academic performance of the students who used the process. I was pleased that a statistical analysis of final exam scores indicated enhanced overall performance of students in the test group of over 6%.*



## Chapter Seven

### *Implications*

It would seem that the straightforward response is to say that 'the performance of the students who used concept maps as a part of their normal study routine, scored significantly higher on the final exam'. This is a true statement, but not the entire message implied by this work.

#### 7.1 Problem-Based Learning

My experience facilitating 2<sup>nd</sup> year students has certainly coloured my interpretation of this data. In the previous chapter, it could have no effect on the statistical analysis of raw data, but it does provide insight into the possible dissemination and application of this work.

##### 7.1.1 Main Issues

The durability of the initial label ('main issues') selected by the students is rather striking. The example used in the previous chapter is illustrative of the potential for controversy in this area. As administrators and teachers in medical education are we so concerned with the, possible, negative connotations of the term 'mental illness' that we should try to remove it entirely from the minds of the students.



In the past few years western society has become inundated with a deluge of preferred terminology in an egalitarian effort to be PC (politically correct). The stimulus for this movement was to remove both real and imagined disparaging implications associated with differences in sex, race or religion. The majority of the educated population applauded the notion if not the reality of this effort. However, it has continued to expand its circle of influence and is now difficult to determine whether it is intended seriously or as a joke.

During this research, the term mental illness was put forward by the students and utilised in a conversation, 'brainstorming', with their peers and then later in highly personal concept maps. I would not expect these students to use the term in a clinical situation, though an accidental usage would be far more likely from this group than from the one opting for the term mental health. Nevertheless, this does not answer the question as to whether the medical faculty should be involved in altering this process. In fact on my third or fourth time through listing the pros and cons of the argument I found a new player to the game, the Internet.

In this era of information technology the Internet is occupying an increasing portion of both academic and leisure time. For most of us it is commonplace to call up a search engine and enter a query. To pursue the previous example, I would expect a high percentage of the students who had used the term 'mental illness' earlier to use it in a web search. I used the two terms 'mental illness' and 'mental health' and perhaps not surprisingly came up with overlapping but substantially different lists of data-bases. This would imply that the two groups of students would be exposed to substantially different information. It must be stated that the choice of one term or the other did not appear to affect the subsequent performance of either group. Upon reflection it would seem that the Internet has merely served to amplify the psycho-social issues of our original concern.

At this point you might think if there is any concern at all, why not change the offending term? The only way to change it would be to intervene at the time students are selecting the 'main issues'. One of the groups that had used the term 'mental illness' as a main issue had changed to the term 'mental health' in their questions and still 'mental illness' proliferated throughout their maps. It would appear that the selection of 'main issues' and then the 'brainstorming' has sufficient impact to



solidify the internal layers of the students concept of the scenario. The ability to alter the labels given these internal layers of concept formation must be undertaken at the earliest possible stage. The problem here is that a primary attribute of the PBL process, and it should be a primary concern of education in general, is the highly personal and individual nature of learning. It would be very difficult for all but the most skilled facilitator to slide in and out of the group and leave no trace. It is my concern that an attempt to alter the selection of the students' 'main issues' would be interpreted by the students as either a mistake on their part or that they had limited freedom. Either case is likely to receive resistance and argument for its own sake.

I am afraid I am still unable to come down on one side or the other regarding this issue. From an administrative point of view as much as I dislike leaving such decisions to be evaluated on an individual basis, that would be my stance here; my inability to come to a conclusion only serves to deepen my ambivalence.

Hypothetically, what if it had been predetermined to intervene? The facilitator would be forearmed with the term they want to promote. At the moment the offending main issue is selected, 'mental illness'; the facilitator must respond, 'let's use the term mental health'. If done skilfully, the students will not be offended because the implication is for all of us to change, seeing at once the superficial sense of it and not wanting to break their own momentum they may accept the suggestion in stride. It is only conjecture that this intervention would alter the personal mental labels used by the individuals. This research clearly illustrates that intervention after this early stage has little to no effect.

### 7.1.2 Questions

As found in the previous chapter, the number or wording of the questions, generated at the end of the brainstorming phase of the small group process, appears to have little impact on the information gathering of the students. This is not to imply that the questions serve no purpose. They provide an opportunity for the students to practise the selection of relevant bits of information and further, in the social environment of a small group, they must agree on the precise wording of the questions they will take away to answer. This is an exercise in diplomacy that along with their academic knowledge will serve them well in the clinical environment. As their undergraduate



education continues and general information gathering is replaced by actual diagnosis, the precise wording of the questions will take on greater importance.

### 7.1.3 Scenarios

The scenarios are carefully written or selected to highlight knowledge needed by the students. It seems unfortunate that, once the scenarios have stimulated the need, they are all but discarded. The collected concept maps rarely identified the relevant bits of the scenario. Questionnaires and interviews indicated that a number of students did not think that understanding the scenario was important for further study. I spoke with four of the facilitators and asked them directly 'after the students have finished their debriefing (giving the answers to the questions generated in the previous session) do you have them tie this new information back to the scenario?'. The answers ranged from 'yes, almost always' through 'sometimes' to 'no, almost never'. One of the facilitators mentioned that some of their questions referred directly to the scenario. It is true that a few of the questions stated, as seen in or as described in the scenario. However, this reference to the scenario was not to further understanding regarding the scenario but to establish the depth of knowledge sought. This is a necessary benchmark in that throughout their study the students will continue to revisit a number of these issues at greater and greater depth. The scenario stimulates thought and then stipulates the depth of that thought but that does not exhaust its potential.

When I was facilitating 2<sup>nd</sup> year students I informed them at our first session that I was reserving five to ten minutes at the end of each debriefing. I used this time to have the students put the information just given in the debriefing to use. First I completed the circle by having them explain what was happening in the scenario. The scenario had provided the initial stimulus, it had stipulated the depth of knowledge and now it provided an opportunity to put the pieces back together. From the scenario I would expand to 'what if' questions, changing one or more of the conditions in the scenario. Without exception each new group expressed surprise at this procedure, indicating that none of the other facilitators had them do this. I do know that at least two of the facilitators regularly use 'what if' questions to verify students understanding during the debriefing. However, their surprise supplied more evidence that utilising the scenario in this way was not the norm.



Once the students focused on my questions, rather than why they were being asked, they had little difficulty finding the answer. From the perspective of the facilitator these were very rewarding brief sessions. The students had just expressed a great deal of information during their debriefing. Now they were being asked to select bits of this information and arrange it in order to answer the questions being asked. These questions were not intended as severe academic challenges to the students as this would appeal to only one or two members of the group, but as exercises with which all members should be comfortable. It was rewarding to see the satisfaction reflected in the faces of the group as the pieces fell into place. It is my contention that these few minutes of applying new information rather than regurgitating it has significant impact on long range remembering and understanding.

## 7.2 Concept Mapping

From the outset the hub of this research has been the Concept Map (Mind Map). Whenever I discussed it with colleagues they would immediately focus on Mind Maps bringing to the fore their preconceived notions and opinions. This meant they saw the research as being about the 'tool' not about the work it was doing. My goal was broader for two reasons. First, this was my work and beyond the obvious 'did concept mapping improve academic performance', I wanted the students to interpret and utilise the 'tool' in their own way, hopefully shedding some light on how and why it worked. Second, despite being drawn to the theory of concept mapping, I felt that, in practice they were being used in ways that severely restricted their appeal and destroyed many of the theoretical constructs (Chapter Two) on which they were founded.

### 7.2.1 Number of Nodes

How can an individual produce concept maps (based on diverse scenarios) that contain the same number of thoughts, yet are unique in all other respects? A completed concept map is a visual representation: perhaps this phenomenon is a manifestation of visual acuity. There has been a significant amount of research on the accuracy and limits of our senses. Visual acuity has been measured by randomly placing a number of symbols on a screen, briefly exposing it to the subjects, and then asking how many were there? The results of research on visual acuity show surprising accuracy up to a point, that point, much closer to eight than eighty, was



roughly analogous to a single 'working space'. I do not think visual acuity explains this situation.

What is being measured here is the number of individual thoughts conveyed by the maps, irrespective of how they are expressed or linked. Perhaps we are dealing with an internal counter or framework of some kind. If we accept the students' cut-off point, as what they can realistically hope to remember, then we must accept that this cut-off remains static over time. Is it reasonable to accept that over weeks and months the ambition, interest and goal of the student remains the same? Perhaps not reasonable, but possible. If the theoretical endpoint remains fixed, is it possible that a subconscious counter keeps track of the thoughts and lets us know when the buffer is full? Not a counter that knows that 34 thoughts have been covered so far, or that the buffer is half full, but one that continues to record the completed thoughts and is aware when a predetermined endpoint has been reached. I cannot honestly believe that this is the answer, but it may be the right area of enquiry.

### 7.2.2 'Good' Maps

When this research began, I strongly suspected that the intimate relationship between a concept map and its creator would mask the power and significance of the map to a second party. In the light of the previous chapter this suspicion seems well founded. Does this mean that a concept map is not an appropriate form of assessment? I will try to answer this question and because of my expressed opinion regarding the idiosyncratic nature of the process you may be surprised at the cautious, circumspect nature of the answer.

What is a 'good' concept map? After failing miserably to make this determination by objective or subjective means, I conclude that a 'good' concept map is one that helps an individual to learn and remember. The personally created maps, utilised in this research, enhanced the final exam scores of the students. In this sense these are 'good' maps. It could be argued that the consequence of the mapping process can be assessed, but not the map itself. I accept this reality but want to know why?

The reader may think that I have tried to assess the maps and yet have ignored the one attribute of the maps that is assessable, the content. Because the students could have had outside help with map construction an analysis of map content is not



particularly meaningful. In constructing their maps the students were essentially selecting among an excess of correct choices. I am not convinced that this situation would have been significantly different if the students had been restricted to the resource of previous knowledge. Consider two hypothetical cases: in one case the student selected 50 nodes from an unlimited pool, in the other case student the selected 50 nodes from the 75 they had in their mind. I suppose more to the point, compare the student who selected 50 nodes from 75 to one who selected 50 from 250. All of these cases yield a concept map with 50 nodes that may convey essentially the same information. The strength of this type of concept map is not what is transferred to paper but the amount of information the selected nodes spark in the mind of the student.

You will have noticed that I said this type of concept map. There are different types. Before I discuss the different types I want to continue with the problems encountered in my attempt to assess the maps generated by this research. Let us further examine the two maps just discussed, one in which the student showed 50 nodes from a base of 75, the other in which the student chose 50 out of a 250 node base. Both convey the same information to the assessor, or do they? The aesthetic qualities of the layout cannot be wholly ignored. The desire to utilise concept maps for assessment is largely due to the notion that they should measure the same knowledge as the tried and true essay, but without the labour intensive, time-consuming marking associated with essays.

For the moment ignore the fact that an essay is an excuse to write down everything you know and a concept map is an excuse not to, and therefore may not measure the same attributes. I think we all will defend our ability to appreciate a Nobel Prize winning essay. However, what about two essays that say essentially same thing but are presented in radically different forms? One essay is written in beautiful easy to read calligraphy, with straight margins and no scored out words. The other exhibits the penmanship of an eight year old, with ragged margins and many words crossed out. We want to say that the two essays receive the same grade, as they should. The reality is they probably do not. In part this is understandable since the essay that is well presented and easy to read takes far less time and does not detract from the messages being conveyed. The other essay takes more time and effort and the line of



thought becomes lost. For these reasons the two essays may not convey the same information even though they both contain the same data. The other reason the two essays may not receive the same grade is less tangible but no less real. Consider the multi-billion pound industry of marketing, the sales of a product may be dramatically affected by changing the colour or shape of the container. This is not necessarily a matter of trivial concern. The abbreviated style of a concept map reduces the volume of information conveyed but can increase the impact of aesthetic presentation.

The concept maps utilised in this research are highly personal learning tools; they are solely for the benefit of their creator and they constitute only one type of concept map. The better known type, favoured by Novak (1984) and Buzan (1979), is a map that of itself conveys information. It is my contention that this type of map is erroneously assumed to convey information to its creator as well as to a second party. If the students involved in this research had created this type of map they would have tried to tell me what they thought I wanted to hear. It is an entirely different thing for the students to ask themselves 'what is happening here' than for them to tell me 'this is what is happening'. In the first instance the strength of the map is the number of nodes (amount of information) it sparks in the mind of its creator, in the second case the strength of the map is the number of nodes it sparks in the mind of a second party.

Having made clear the delineation between the two, the question to be addressed is 'does this second type of map provide an accurate representation of an individual's knowledge and can it be fairly assessed'? Whether it is an accurate representation of an individual's knowledge is a purely subjective, circular argument that will not yield a consensus in any court.

Can this type of map be fairly assessed? Let us dispense with the deep philosophical questions that bubble below the surface of any attempt to judge another, and answer in relative terms. I have mentioned that the desire to use concept maps for the purpose of assessment is the belief that they would measure the same attributes as the essay. An essay provides an opportunity for the student to tell us everything they know about a topic. If the essay is coherent, indicating a logical progression of thoughts to an appropriate level of detail, it receives a good mark. As the assessors read through the essay they are chunking and linking the ideas in their own minds so



that the essay ends up receiving a mark based on the amount of information directly and indirectly sparked in the mind of the assessor. If the author of this same essay had produced a concept map instead, then they would have already chunked and linked the information before presenting it for assessment. The more closely their framework of chunks and links matches that of the assessor the better mark they receive. Conversely, the greater the difference between the internal framework of the assessor and that of the student, the lower the mark is likely to be. This same problem exists when assessing an essay but its impact is likely to be small. Therefore, by drastically reducing the amount of information to be assessed we have drastically increased the impact of the personal bias of the assessor.

This personal bias cannot be removed from any subjective assessment. However, the stimulating, thought provoking attributes associated with allowing the student to create their own answer can never be mimicked by having them choose among pre-selected responses. The goal is to reduce the impact of the bias to an acceptable level. There are ways of reducing this bias in a student-created concept map. There is a need to provide the student with some insight into the way you chunk and link information or what level of detail you expect to see in their map. This type of map is supposed to convey information, if the students understand the topic it is quite reasonable to ask them to chunk and link it in the manner you want regardless of its similarity to their own design.

The 'key concept' to be expanded or explained is the topic under assessment. By providing another point in the map you are asking the student to use their understanding of the concept to put together a puzzle. This is a reasonable and assessable request. My previous concerns regarding the aesthetic presentation of the map are still valid, but their impact is reduced by partially specifying the content and therefore shifting your attention as well as the students' to the chunks of information and not their presentation.

Furthering the notion of this being a puzzle for the students to solve you can specify the location of pieces. Start with the 'key concept' and then indicate the links and the placement of the nodes but not their content. Then, by specifying the content of a few nodes the students are left with a frame and a few complete pieces. This can be a



challenging puzzle for the students to solve and the aesthetics of presentation have been completely removed.

Is concept mapping a good form of assessment, in the sense that it accurately indicates the level of competence of a student within a population? I cannot say, but it has a number of factors in its favour. The students should find this type of question interesting, challenging, an opportunity to manipulate and use their knowledge not just regurgitate it and difficult to anticipate precisely. These are certainly the features of good assessment.

### 7.3 This Research

This research is about concept mapping. No, that was the tool that was used. This research is about Problem-Based Learning. No, that was the environment in which the tool was utilised. This research is about understanding and remembering, it is about learning.

The theoretical foundations of concept mapping and PBL are similar. Both are deeply couched in learning theory. The question is, why do they work, why does this research indicate a statistical advantage for students who used the concept mapping process? The process utilised in this research allows the student to use newly covered material not just to memorise it. In the traditional education format, I have heard a number of students say that the point of greatest understanding is when they leave the exam, not when it began. In traditional education, the exam was probably the first time the students were asked to condense and utilise the information they had been struggling to memorise. There is nothing particularly special about the final disposition of the 'chunks and links' depicted in the concept maps. What is special is the process of forming them, which provides multiple points of access to the student's data-base. The strength of the concept mapping process is not increasing the size of the student's data-base but in increasing its malleability and flexibility.

Problem-Based Learning is not problem solving, nor should it be. However, if the problems (scenarios) are used only to stimulate inquiry then the data subsequently gathered will be filed in serial lists. This would reduce the strength of the PBL process. It is neither necessary nor desirable for the problems to be difficult and demanding. The proper process is analogous to training for an athlete. They practice



skills over and over, not under game conditions but at half speed. This training prepares the athlete for the rigours of the game.

## 7.4 Rhetoric

I find myself treading carefully, gingerly placing one foot in front of the other mindfully resisting the old adage to get off the fence. To the biochemist and the physiologist, I am the soft wind of art and philosophy. To the psychologist and educationalist, I am the hard-nosed voice of the bench scientist. As I walk this perilous path I am constantly poked and prodded by long staffs from either camp. They do not invite me into their billet but attempt to topple me into the opposing one.

Despite my expressed discomfort with this position I am convinced that it is in the best interest of the students. These opposing views are centred on differences in method not in the ultimate goal. I am not concerned with the duplication of research efforts, results should be verified by repeated efforts from various angles. The problem arises from not utilising the lessons learned in one area to the implications and practical application of work done in another.

During this research it has been my good fortune to work with an interested and progressive Faculty. The medical faculty having recently adopted the PBL process for their undergraduate curriculum was keen to evaluate its impact on the students. In addition my subjects were academically gifted and highly motivated. Together they provided an excellent opportunity to test my ideas. It is my hope that the implications of this research, that seem so obvious to the researcher, have been adequately conveyed.

*“And in much of your talking, thinking is half murdered.  
For thought is a bird of space, that in a cage of words may indeed  
unfold its wings but cannot fly.” (Kahil Gibran, 1926)*



## Pertinent Findings and Proposed Research

### Problem-Based Learning

- ◆ The 'main issues' selected by the students', manifest themselves as remarkably static anchors in the expanding cognitive data-bases of these students.

*Despite the small sample sizes I do not feel this result requires further verification. Can the precise wording of these anchors be changed in the minds' of the students? This question was explored in Chapter Seven and remains to be answered.*

- ◆ The quantity or precise wording of the questions appears to have little affect on the subsequent information gathering of the students.

*This result was not anticipated. However, the general nature of the information gathered by these first year students is a plausible explanation for their lack of reliance on the questions. It is hypothesised that as the students' progress through their medical training the quantity and wording of the questions will take on greater importance. This remains to be experimentally verified.*

- ◆ The ability of a Facilitator to unknowingly or unwittingly influence the goals and desires of the group is not directly observed in this research, but only inferred.

*The affect of Facilitators on their students has been and will continue to be the subject of many research projects. The potential negative influence that is inferred in this work should never be a direct research goal. Administrators or researchers should never knowingly allow a negative environment to proliferate.*

- ◆ The scenarios that provided the initial stimulus for information gathering by the students are all but discarded after providing the need to know.

*The theoretical constructs of PBL include the creation of multiple avenues of access to information contained in the Long Term Memory of its' students. It is understood that time constraints are a limiting factor, but the scenarios can and should be utilised to further establish these avenues of access. Research comparing students who use multiple scenarios to those who do not should elucidate this point.*



## Concept Mapping

- ◆ Approximately 20% of the students produced concept maps of diverse scenarios that differed in map layout but contained the same number of nodes (thoughts).

*This was a totally unexpected and inexplicable result. This physiological / psychological manifestation should be elucidated. It would be interesting to compare brain scans (PET, MEG, ...) of students that exhibit this trait to those that do not.*

- ◆ This research was unable to determine the academic potential of the students on the basis of their personally created concept maps.

*The growing tendency to use concept maps for assessment should be re-evaluated, especially in light of the similarities between the maps of students at both extremes of academic performance.*

- ◆ The highly personal concept mapping process, utilised in this research, significantly enhanced the academic performance of all students who used the process.

*The concept mapping process, utilised in this research, should be applicable to other disciplines. It should be equally effective in traditional education formats.*

- ◆ This research indirectly infers that the thoughtful manipulation of newly learned material is more effective than traditional study methods for helping students understand and remember.

*This is not a new idea for educators but it is rarely explained to or utilised by students. When teachers attempt to have the students utilise this finding they concentrate on what the student should do and rarely explain why. Metacognitive awareness of the students will allow them to choose a study method more personally suited.*



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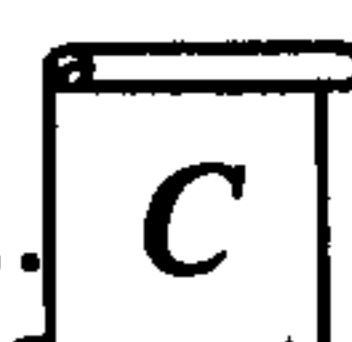





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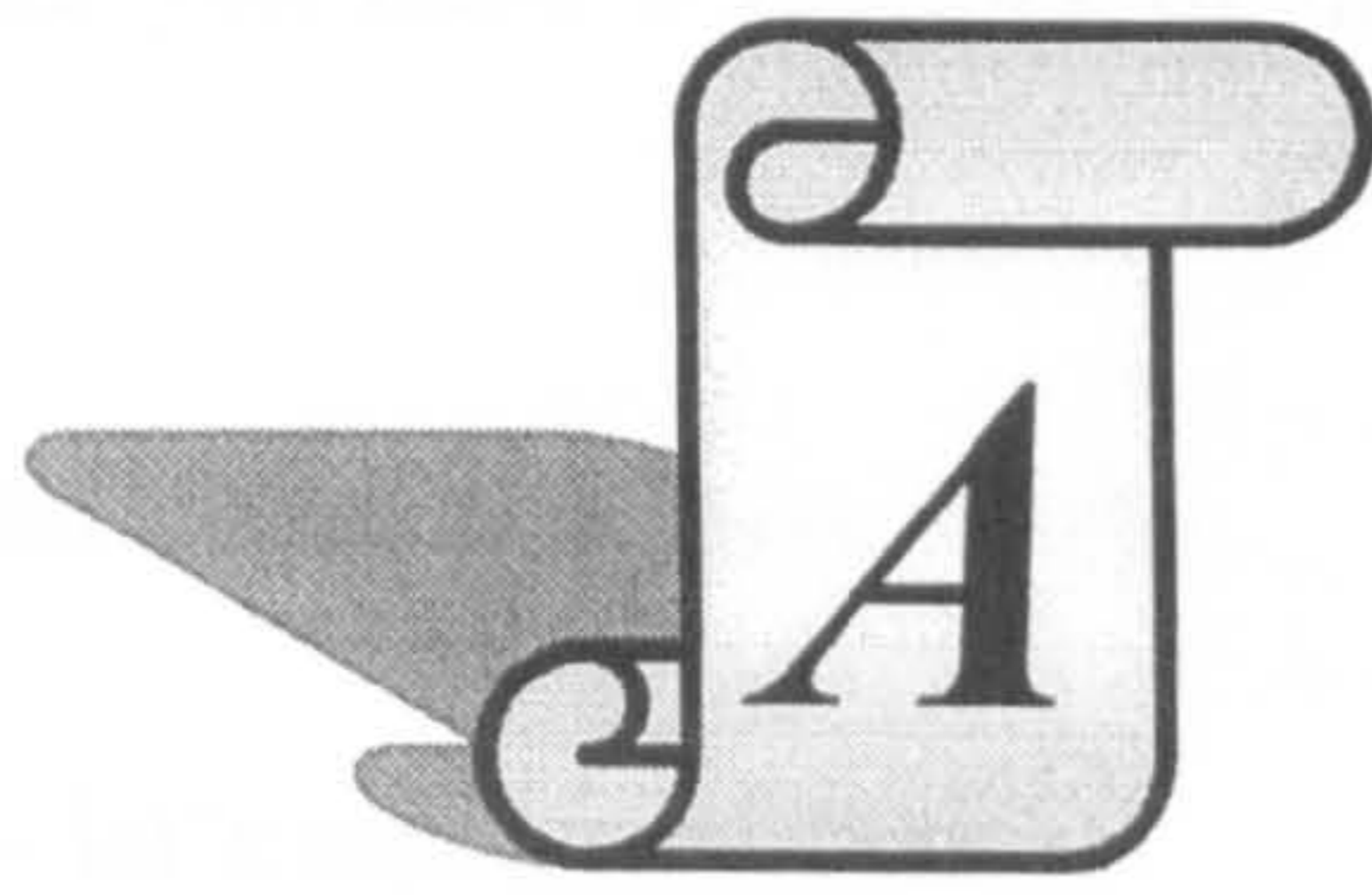


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The anonymity of the students has been preserved by using student numbers and coded exam scores.





## *Appendix A*

*Lecture notes and handouts from my first contact with students.*

***Lecture notes* ..... A1**

***Handouts* ..... A5**



As first year PBL students you have a number of new experiences with which to deal.

University life – can't help you there, enjoy.

The PBL process – let's talk about that.

This style of education has evolved over the last 30 years. All of the best bits are being utilised here at Glasgow. PBL is an alternative to traditional education, as such PBL students have been continuously tested against their traditional counterparts. The research indicates that after two years the PBL students consistently do as well or better than students from a traditional program. In the area of student attitudes the PBL students always rank higher. With the idea that happy students learn more, enjoy.

For the student, what is the primary difference in the PBL process? As learners mature their learning shifts from being teacher centred, there is only one right answer to the question and the teacher will tell me what that is, to student centred, there are different views on the subject and I am going to look at several opinions before I decide on an answer. The PBL process requires you to take this step.

You are all very good students or you wouldn't be here. At this point the question is not whether you will learn the information, you will, but what can you do with the information. Even with the most basic problem, no two students will present in exactly the same manner. You must draw on a substantial data-base and manipulate the pieces to see if they fit the current situation. This ability does not come automatically, it must be planned and practised. How?

First, be aware of a couple of potential problems, serial learning and context specificity.

Serial learning is a type of rote memorisation. A great deal of information can be held in this manner, but its usefulness is very limited. For example –

In the States most primary students learn the states and capitals. This information is of no practical value. However, many years later adults can remember most of them. But if you ask what is the capital of Florida – they have to start with Alabama and proceed



through the list before reaching Florida. Another example might be song lyrics. Even if you are given the title of a song, you can only remember a few lines and they may be in the middle. But, as soon as you hear the first few notes the words just flow.

Context specificity is the inability to transfer information from the context in which it was learned. For example –

Medical students in Canada were tested during the diagnostic phase of their education. When questioned about patients with existing or potential heart problems, 90% were aware that aspirin is commonly prescribed and that a possible side effect of prolonged use is the spitting up of a small amount of blood. However, when presented with a patient in reasonably good health, no prescribed medication, a history of mild arthritis, spitting up a little blood for a few days – less than 30% saw the seemingly obvious answer. The patient had been self medicating with aspirin.

Here the students had a very good understanding of the concepts involved and how they link together. But, this information could only be accessed by a single route.

So how can you improve the usability of your information? One way, not the only way, is what I call Concept Mapping. Concept Maps are similar to Mind Maps with which you may be familiar. The primary difference I make between the two, is that Mind Maps are used for planning and I am advocating the use of Concept Maps for retrieving information. Concept Maps take advantage of the brains natural tendencies. They are based on direct associations.

NOTE – Before proceeding with the positive attributes and the procedure for Concept Mapping, a word of caution. Concept Maps are not good for learning a serial list of facts or detail. They are good for finding (reminding you of) specific facts.

Now back to the Concept Map commercial. As I mentioned previously Concept Maps take advantage of the brains natural tendencies. Such as –

The chunking and linking of information

The brain is the ultimate information processing mechanism. As a very superficial explanation it can be divided into Short Term Memory (now called Working Space) and Long Term Memory (LTM). When something is learned it is stored in the LTM, which is virtually limitless. In order to use this information it must be



accessed and retrieved through the Working Space, which is finite. In an effort to compensate for the limits of the Working Space we chunk information. This chunking allows us to bring more information to bear on the problem at hand. Concept Maps are a way to visualise chunks of information and how they are linked in our cognitive network.

### Parallel processing

To some extent, perhaps a large extent, the different hemispheres of the brain handle different functions. For most right-handed people: the left hemisphere handles number skills, written language, reasoning, spoken language and scientific skills; the right brain handles insight, 3-D forms, art awareness, music awareness and imagination. These divisions are certainly not totally rigid. Concept Maps appeal to many of these areas and in an effort to store and retrieve information, why not activate as many brain cells as possible!

Now that you know why, how do you use Concept Maps? There are a number of books on the subject of Mind Mapping. Some of them aren't bad, you might try one by Tony Buzan. If you do just look at the chapters describing the process and be aware that this process should be highly individualised. Once you understand how they work, develop your own style. No two people are the same, you can't compare your map with your classmates. The strength of a Concept Map is not in what you see, but in what you don't see. You are the only one who knows if your map is good or not.

You begin with a 'Key Concept', which is the primary stimulus for your inquiry. Turn your paper in landscape fashion (just to give you more room to expand). Place the 'Key Concept' in the middle of the page (print – bold caps are the easiest to read). To the 'Key Concept' you want to link concepts that are directly associated. Concepts should be limited to a word or two, as you add concepts do not turn the paper (keep your map easy to read from a single view). The number of direct associations will vary from person to person and from one 'Key Concept' to the next. Once the direct associations have been made, level 1 is complete. You now move to level 1 concepts and expand them by direct associations. Limit the expansion of your map to one level at a time, do not follow a single line of thought three or four steps and then return to the 'Key Concept' for the next branch. This restriction is a result of research in learning theory which would take much longer to explain than it would



be worth to you. Basically you want to make and break links over and over, not follow three or four individual lines of thought from the 'Key Concept'. As you continue to expand your map in this fashion a concept may be expressed using symbols or drawings instead of words. As mentioned earlier, appeal to as many brain cells as possible. Drawings should be very simple, humorous perhaps. Remember it's not what you see but what it reminds you of that counts. Use colour to aid memory, not to signify importance. At this point in your education you just need to understand all the pieces. Later, much later, when you begin diagnosis you will start to weigh the importance of the relevant bits, not now. Your completed map should be balanced on the page. If it is not balanced it will be a distraction and the strength of this tool is its comfortable fit in your information processing system. A well considered, well constructed map should remind you of the links between all the facts and detail within your cognitive network. They don't openly display this information. Study and revise your maps as needed.

If you have any questions or comments about Concept Maps, study skills or the general process of PBL – please ask.

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## **META-COGNITION**

What is meta-cognition?

‘thinking about thinking’ .....

.....**thinking about Your Own thinking**

Be aware of and beware of...

## **SERIAL LEARNING**

May also be referred to as a type of rote memorisation. Much of traditional education encourages this method. The information is strung together head to tail with no points of access. Information may be held in this manner, but is not easily usable.

i.e. song lyrics – Even if you are given the title, you can only recall a few lines and these may be in the middle. But, as soon as you here the first few notes – the words flow.

## **CONTEXT SPECIFICITY**

Is the inability to utilise knowledge outside the framework in which it was learned. The concepts and ideas may be well understood, but they are only accessed via a single route of inquiry.

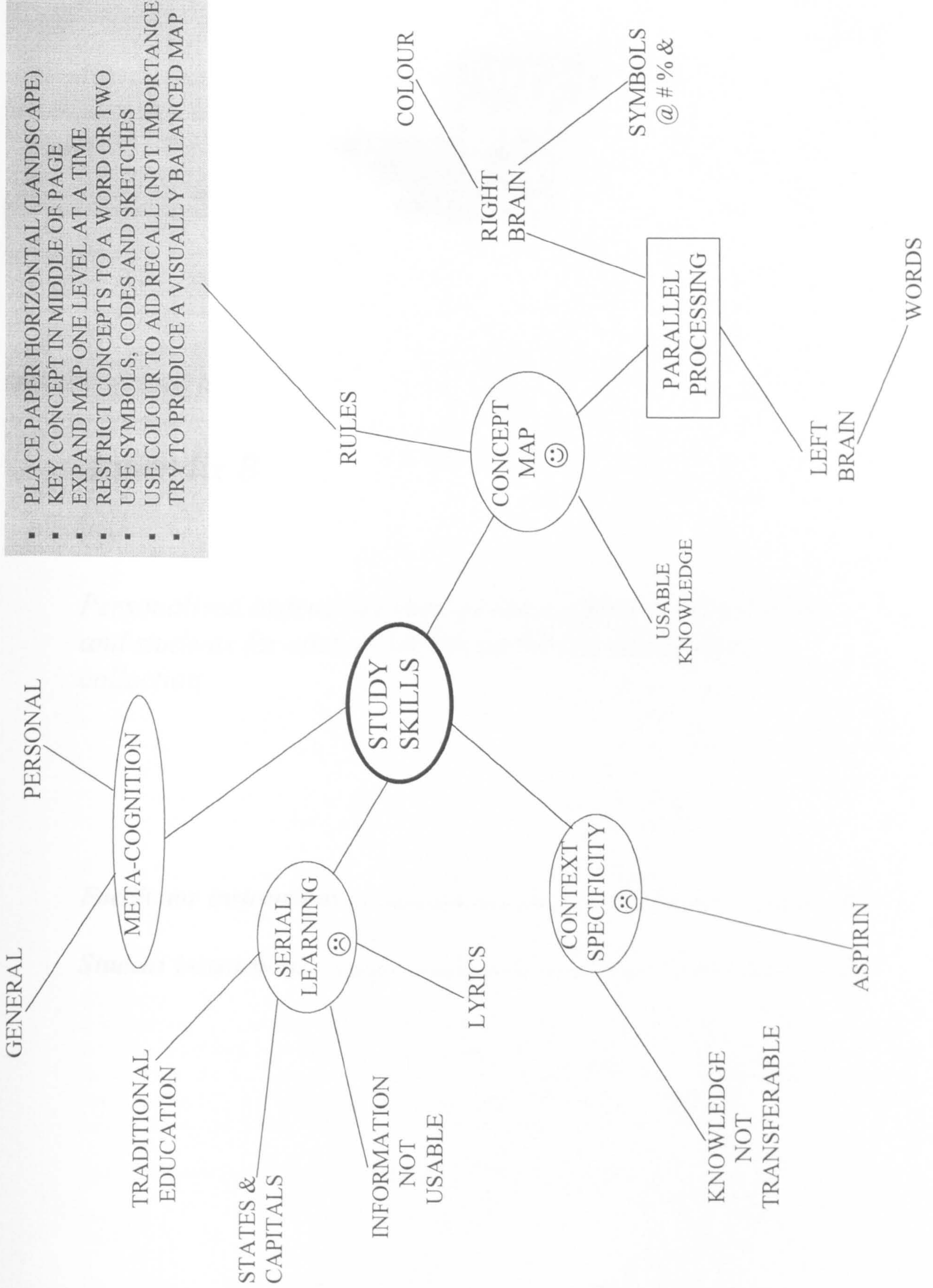
Take advantage of....

## **CONCEPT MAPPING**

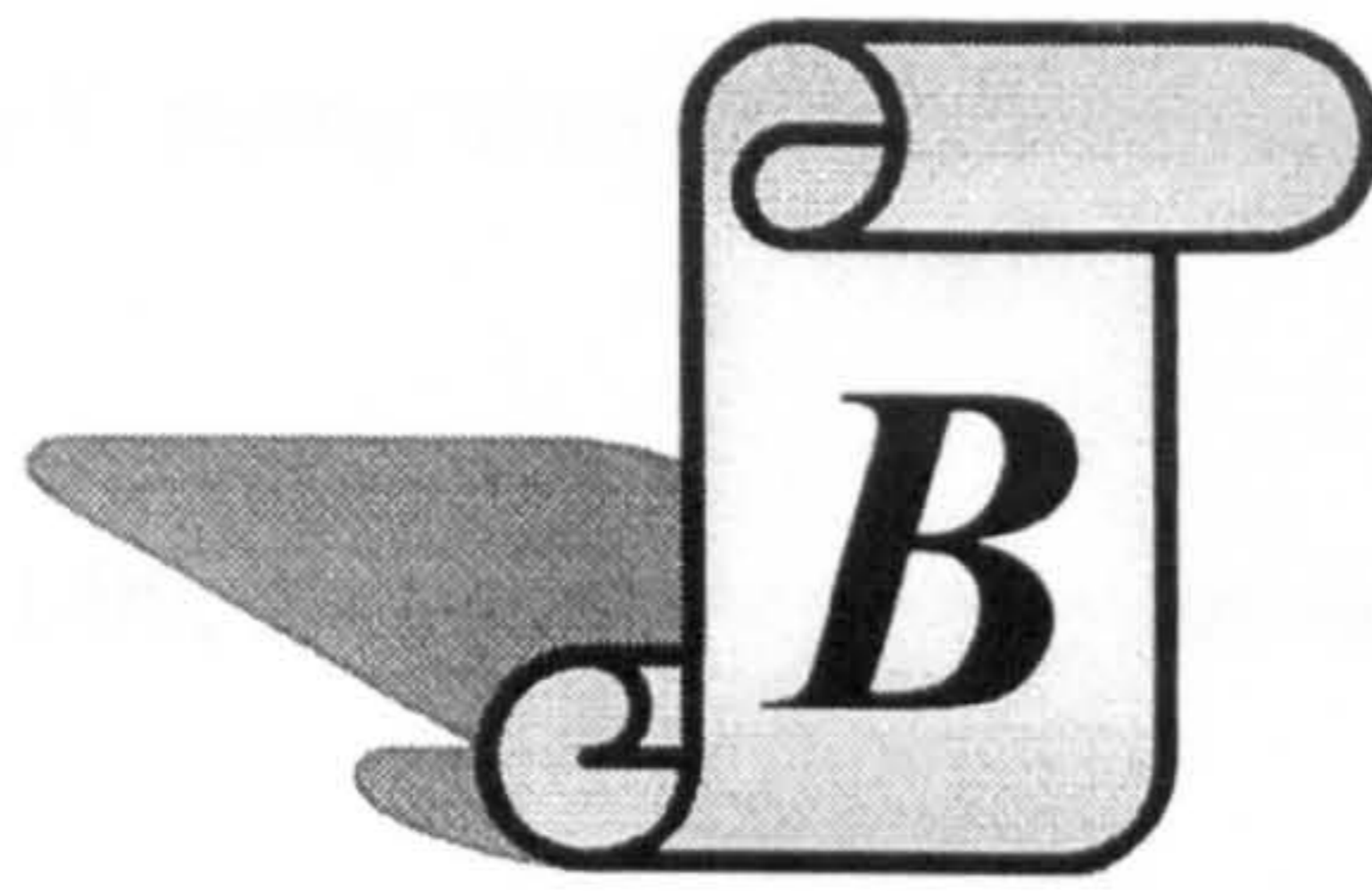
Concept Maps (Mind Maps) appeal to many of the brain’s natural tendencies. Association is the device our brain uses to make sense of our physical experience – the key to human memory and understanding.



- PLACE PAPER HORIZONTAL (LANDSCAPE)
- KEY CONCEPT IN MIDDLE OF PAGE
- EXPAND MAP ONE LEVEL AT A TIME
- RESTRICT CONCEPTS TO A WORD OR TWO
- USE SYMBOLS, CODES AND SKETCHES
- USE COLOUR TO AID RECALL (NOT IMPORTANCE)
- TRY TO PRODUCE A VISUALLY BALANCED MAP







## *Appendix B*

*Personalised instruction sheets were supplied all facilitators and students for each of the ten scenarios during data collection.*

***Facilitator instructions..... B1***

***Student instructions..... B2***



Dear , <NAME>

I am collecting data from group C during block 3. My research interest is in the way students *chunk and link* information.

### Procedure

Beginning on Thursday, 14/1/99, an envelope with your name on it will be on the shelf where you pick up new scenarios.

It will contain:

- (i) a 2 part NCR form for the facilitator and
- (ii) a 3 part NCR form for each of the students.

As the students proceed through the GLASGOW STEPS please:

- (a) record the main issues and the groups questions on your 2 part form,
- (b) tear off the bottom sheet and return it, in the envelope, to the shelf at the end of the session.

The top sheet may be kept for your records.

Beginning Tuesday, 19-1-99, the returned envelop should contain the sheets returned by the students on the previous scenario.

### Students' Procedure

The students complete their form before returning to the next PBL session. For your information and in case any questions arise, here is the general idea.

- After the students have answered the agreed upon questions, they put away their notes and take out their form and a fresh copy of the scenario (provided).
- Using the scenario as the starting point (central node), they branch off to directly related concepts and from these concepts they branch to concepts directly related to the previous.
- The students continue this expansion, in mind map fashion, to illustrate how *they* understand the scenario. This process is intended to be of a self-test for the students and should take only a few minutes.
- Upon completion the students tear off the bottom page of their 3 part form.
- They then take out their notes, text, etc. and make whatever corrections and additions they like.
- When finished they tear off the second page of their form.
- The top page is retained by the students as it should serve as one page retrieval aid for the information covered by that scenario.
- The bottom two pages are placed in the envelope at the beginning of the next PBL session.

This process should continue for 10 scenarios.

It is expected that the students will have to practice these techniques for 2 or 3 scenarios before it becomes an effective part of their learning process. When the process becomes familiar it will facilitate the mental storage and retrieval of information. It will be stressed that these 'concept maps' are highly individual and can not be compared with one another. *Their strength is not in what a second party sees in them, but in what the creator understands from them.*

PLEASE contact me if you have any questions or comments.

Sincerely,  
Kevin

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Kelvin Building 243D  
[K.Otis@chem.gla.ac.uk](mailto:K.Otis@chem.gla.ac.uk)



The following week Mrs Johnstone brings her 16 year old daughter Aileen to the surgery. Aileen is obviously displeased about having to attend but her mother is tense and determined. Dr Green notes that Mrs Johnstone is only 33 years old so she might have been 17 when Aileen was born. Mrs Johnstone is worried about Aileen's weight but, before delving into all that, Dr Green makes some general enquiries about the family. Aileen is worried because she is in the middle of exams.

*Dr Green asks to speak to Aileen on her own.*

Aileen, it turns out, is an intelligent teenager who has more than reasonable standard grade results but is unsure what to do next. She desperately wants to "get out of here and get a life!" She has never been a big eater but in the past three years has become increasingly aware of her weight, always thinks she is overweight (even though to Dr Green's eyes she is very thin) and is "never off a diet". She tells Dr Green that she became a "vegetarian" 10 months ago "for a variety of reasons". Dr Green asks Aileen to keep a diary of just what she eats every day and to bring this back in 2/52 in the hope that it will give her a better idea of the extent of the problem.

<NAME>

When you have finished answering your questions put away your notes and books.

- ❖ Turn your form to landscape position and put your name and matric. number in the corner.
- ❖ Reread the scenario.
- ❖ Use the 'patient' name as the central node, it represents the entire scenario.
- ❖ In 'mind map' fashion expand from the central node.
- ❖ Expansion should be done one level at a time.
- ❖ Use all your knowledge to explain the scenario, whether learned in the last week or in primary school.
- ❖ Try to limit concept nodes to a couple of words and/or symbols; but this is your map and how you choose to represent the ideas is up to you, it should prompt your memory and if that requires a list or a graph at times that is up to you.
- ❖ When finished tear off the bottom page of your form.

-----

- ❖ Take out your notes and make whatever additions or corrections you like.
- ❖ When finished tear off the bottom page of the form.

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The top page should be part of your notes for this scenario.

At the beginning of your next PBL session place the two bottom pages in the envelope provided.

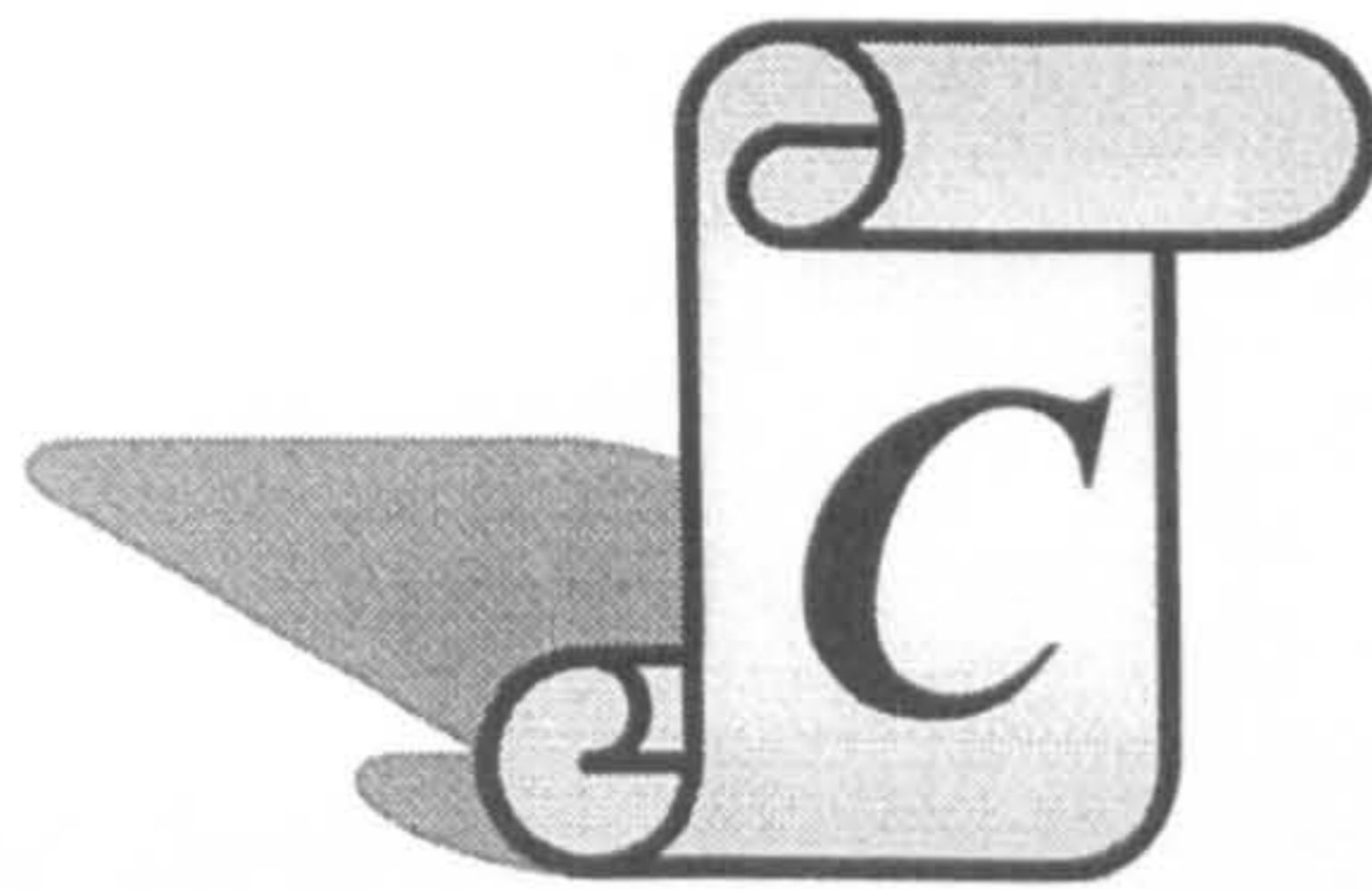
THANK YOU

**Note:** This exercise is intended as a way of accessing and utilising newly learned information. It is not likely that you will be asked the exact question again, but the process is essential to your profession.

Please let me know if you have any comments or questions.

*Kevin Otis Centre for Science Education Kelvin Building 243D K.Otis@chem.gla.ac.uk*





## *Appendix C*

*The ten scenarios on which the collected maps were based.*

<i>Scenario 1</i> .....	<i>C1</i>
<i>Scenario 2</i> .....	<i>C1</i>
<i>Scenario 3</i> .....	<i>C2</i>
<i>Scenario 4</i> .....	<i>C2</i>
<i>Scenario 5</i> .....	<i>C3</i>
<i>Scenario 6</i> .....	<i>C3</i>
<i>Scenario 7</i> .....	<i>C4</i>
<i>Scenario 8</i> .....	<i>C4</i>
<i>Scenario 9</i> .....	<i>C5</i>
<i>Scenario 10</i> .....	<i>C6</i>



## SCENARIO 1

Dr Green had begun to read about the issue of how health was defined. She began to appreciate that health was more than just the diseases people presented with to hospital. However, she read the Scottish Green Paper on Public Health. It said:

*In any year about one quarter of the population will experience some form of mental distress. Not all of these will see their GP and it is not always those who are most ill who go to see their GP – other factors come into play. Of those that do only half will receive any medication. Only 1 in 10 people with a mental health problem are referred to hospital or even to see a specialist. At least 1 in 10 of the 16 million consultations with GPs each year in Scotland involves a mental health problem.*

She discussed this with Dr. Grey who merely mumbled that this is just another illustration of the 'iceberg of illness'. Anxiety and other mental health problems have a high incidence and prevalence but do not always present to the GP and even when they do, it is not always obvious.

Clearly, Mrs Johnstone and her pattern of frequent attendance was part of a bigger picture.

## SCENARIO 2

Mrs Johnstone telephones Dr Green a few days after her most recent visit to the surgery. She emphasises how desperately tired she is feeling and tells Dr Green that she thinks that "she must be lacking in something" to have so little energy. She asks Dr Green if she can have a test to try to find out if her "system is run down". Dr Green decides to ask Dr Grey's advice. He comments that "in the old days they used to prescribe 'nerve tonics' which sometime contained vitamin supplements, particularly vitamin B1". He goes on to say that "there may even have been some science in this, bearing in mind the fundamental biochemistry of energy metabolism".



### **SCENARIO 3**

The following week Mrs Johnstone brings her 16 year old daughter Aileen to the surgery. Aileen is obviously displeased about having to attend but her mother is tense and determined. Dr Green notes that Mrs Johnstone is only 33 years old so she might have been 17 when Aileen was born. Mrs Johnstone is worried about Aileen's weight but, before delving into all that, Dr Green makes some general enquiries about the family. Aileen is worried because she is in the middle of exams.

*Dr Green asks to speak to Aileen on her own.*

Aileen, it turns out, is an intelligent teenager who has more than reasonable standard grade results but is unsure what to do next. She desperately wants to "get out of here and get a life!" She has never been a big eater but in the past three years has become increasingly aware of her weight, always thinks she is overweight (even though to Dr Green's eyes she is very thin) and is "never off a diet". She tells Dr Green that she became a "vegetarian" 10 months ago "for a variety of reasons". Dr Green asks Aileen to keep a diary of just what she eats every day and to bring this back in 2/52 in the hope that it will give her a better idea of the extent of the problem.

### **SCENARIO 4**

Dr Grey is also the police surgeon and invites Dr Green to accompany him on a call to the police station one night. A group of youths had been arrested while attempting a noisy and incomplete break-in to a local off license. The police suspect from their behaviour that they are under the influence of drugs. When they arrive at the police station the doctors find the boys, all in their early teens, to be excitable and a little incoherent but there are no specific signs apart from dilation of pupils.

Dr Green is surprised by her own ignorance. She has been taught a great deal about therapeutics but has only the vaguest ideas about what substances these youths might have been using and their possible consequences. She felt more than a little insecure having to deal with this type of problem.

Dr Green notices the name and address of one of the youths and deduces that this must be Mrs Johnstone's son, John.



## **SCENARIO 5**

The next day Dr Green examines data on the practice GP ASS system. It shows the following. Of the 12,000 patients registered with the practice:

- 32 individuals are registered drug addicts.
- 42% are currently smoking.
- Less than 5% are recorded as having alcohol problems.

However, when discusses this with Dr Grey he makes the point that the patterns in cigarette use are interesting (overall prevalence has been falling but it remains high in social classes IV and V) and alcohol problems in the practice are very common if all the social and psychological (and hidden physical) manifestations are taken into account.

"Indeed", muses Dr Grey, "it would be interesting to discover just what proportion of the practice population have some form of addiction, and the impact of these have on health".

Dr Green thought about the amount some of her friends would drink in the average week and yet she never really thought they had a problem.

## **SCENARIO 6**

Dr Green is interested to see Mr Johnstone's name on the list on her monitor for the morning surgery. Mr Johnstone complains that he has been having increasingly frequent episodes of cough. He seems to cough all the time and almost always "brings up some spit". Mr Johnstone has smoked since he was 12 years old and now admits to smoking 30 cigarettes a day. Dr Green examines Mr Johnstone's chest and prescribes a course of antibiotics.

She asks him to return to see her in 2/52.



## **SCENARIO 7**

She asks him to return to see her in 2/52. (Continued from previous scenario)

Later the same day, Mrs Johnstone takes her youngest son, Jimmy, age 10, to see Dr Gray's partner, Dr Rupert Laurence. Jimmy has recently been diagnosed as having asthma and has to use two inhalers. Jimmy is refusing to take his inhalers and Mrs Johnstone wants Dr Laurence to "make him take them".

Dr Green also takes the opportunity to look up asthma and is interested to note that it is becoming much more common and many cases in children go undiagnosed.

## **SCENARIO 8**

Mr Johnstone keeps his appointment to see Dr Green two weeks later.

When he arrives he is subdued. His cough and spit have been helped to some extent by the antibiotics. Over the past two weeks he has been getting increasingly troublesome chest pain on exertion. The pain is in the left side of the chest and goes down his left arm and up into his neck and jaw.

Dr Green tells Mr Johnstone that it sounds as if he has angina.



## **SCENARIO 9**

*[Before Mr Johnstone left the surgery two weeks ago, Dr Green checked his blood pressure, which turned out to be normal and, took a blood sample for lipids including cholesterol] (Dr Green has the result of his blood test – the cholesterol is 8.1 mmol/l.)*

Dr Green tells Mr Johnstone that, given his risk for heart disease, factors it is not surprising that he has developed these problems. These risk factors and heart disease are very common in the west of Scotland. She prescribes medication and says that she will need to refer Mr Johnstone to Professor Robbe in the cardiology unit in the Infirmary. Mr Johnstone will need to have some tests. He asks if he might need an operation. Dr Green says that depends on Professor Robbe's investigations but some people with angina need to have coronary artery bypass surgery.

Dr Green tells him that he should change his diet and explains that, if he does not make these lifestyle changes, the benefits of any treatment he might have would be short-lived.



## **SCENARIO 10**

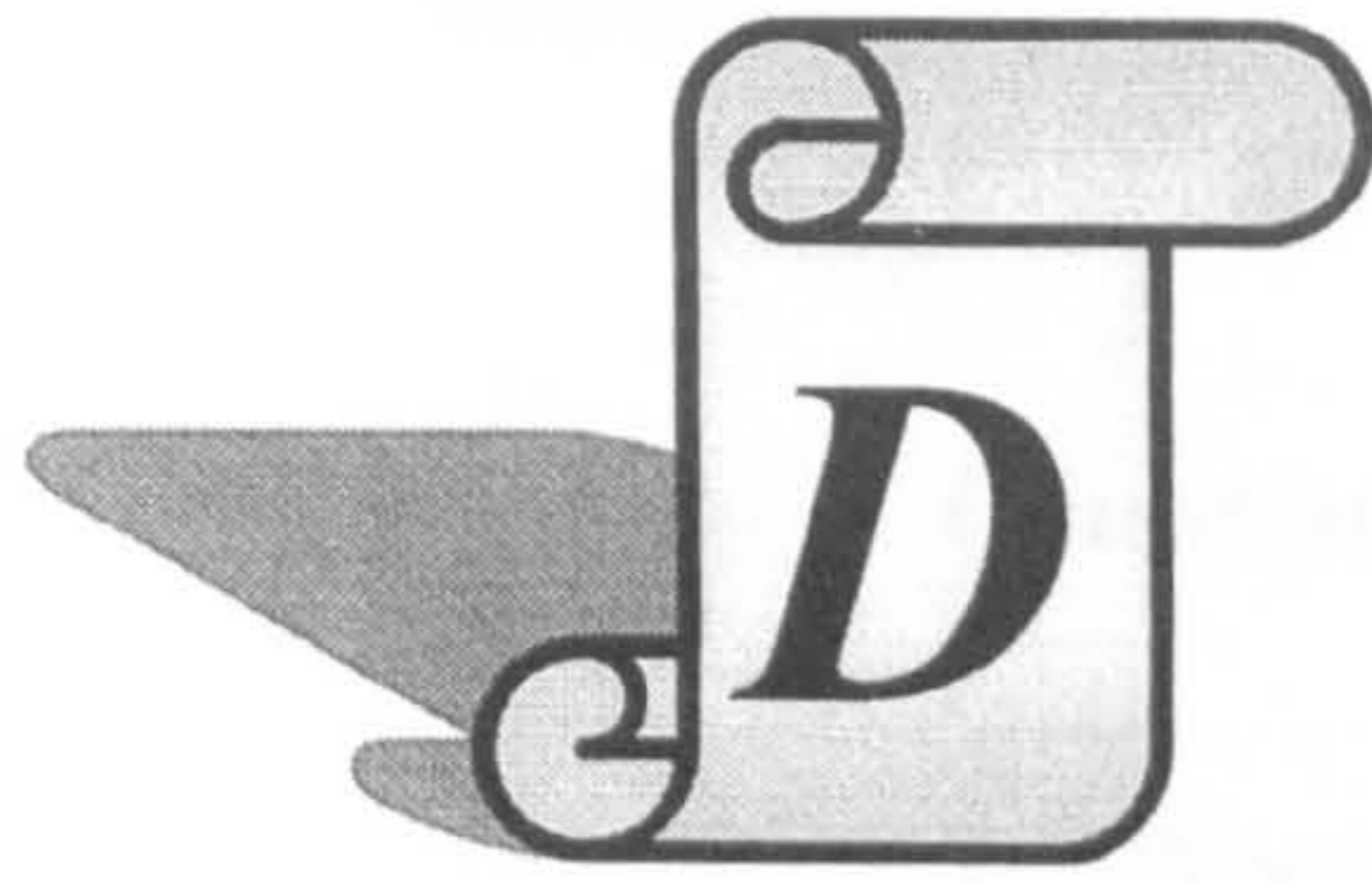
Dr Green decided that she would have to understand more about CHD. She looked up a report on CHD produced by the Scottish Needs Assessment Programme (SNAP). A copy of the full report will be made available to each student.

SNAP's analysis is that, if CHD is to be combated, the people of Scotland need:

1. Social and economic circumstances conducive to accelerating the decline in CHD.
2. Social policies to facilitate health related behaviours that reduce the risk of CHD.
3. Interventions at the level of the whole population to reduce the population risk of CHD.
4. Interventions in those with established risk factors to reduce their risk of developing symptomatic CHD.
5. Appropriate management of CHD at the primary, secondary and tertiary levels of care.
6. Appropriate 'surgical' interventions for individuals with symptomatic disease not responding to medications.
7. Effective rehabilitation and secondary prevention for patients with established disease.
8. Monitoring, audit and outcome measurement of all relevant activities.
9. A co-ordinated research and evaluation strategy

Dr Green could easily identify with objectives 5 to 9 and even 4. However, she was much less familiar with population based interventions and social policies. The report referred to some success that had been achieved in Finland. She decided to find out more.





## *Appendix D*

*Selected questions and main issues.*

<i>Scenario 1</i> .....	<i>D1</i>
<i>Scenario 2</i> .....	<i>D2</i>
<i>Scenario 3</i> .....	<i>D3</i>
<i>Scenario 4</i> .....	<i>D5</i>
<i>Scenario 5</i> .....	<i>D6</i>
<i>Scenario 6</i> .....	<i>D8</i>
<i>Scenario 7</i> .....	<i>D9</i>
<i>Scenario 8</i> .....	<i>D11</i>
<i>Scenario 9</i> .....	<i>D12</i>
<i>Scenario 10</i> .....	<i>D14</i>



## Scenario 1

### PBL Group 30

#### *Main Issues*

Green Paper

Mental Distress

Treatment of above

Incidence/Prevalence

Causes of G.P. visit "trigger"

#### *Questions*

1. What is the aim of the Green Paper (related to G.P.)?
2. Discuss reasons why people choose not to go to their G.P..
3. Discuss triggers for attending G.P..
4. Define incidence and prevalence and relate to this scenario.

### PBL Group 31

#### *Main Issues*

Triggers of going to G.P.

Iceberg of Illness

Defn. of health

Mental health (define, signs, different stages and people)

Common mental health problems

What would cause a stressor to affect mental health

#### *Questions*

1. What triggers a person to go to his/her GP?
2. Describe the iceberg of illness.
3. Define mental health and how it can be identified.
4. Identify the common mental health problems and how they affect the sufferer.
5. What groups of people are most at risk and why?
6. Define incidence and prevalence and how they can be determined.



## Scenario 2

### PBL Group 26

#### *Main Issues*

Vitamin B<sub>1</sub> (supplements)

Biochemistry of energy metabolism

Tests

'Nerve tonics'

Tiredness

#### *Questions*

1. Give a brief overview of the biochemistry of energy metabolism.
2. What are the components of a healthy diet (include food source and function)?
3. What is a vitamin and why is vitamin B<sub>1</sub> necessary?
4. What are the common causes of tiredness?
5. How do you determine the cause of tiredness and what are the possible treatments?

### PBL Group 29

#### *Main Issues*

Vitamins

Energy metabolism

System – rundown

Tests

“Tonics”

Placebo

Patient control

#### *Questions*

1. Review the process of respiration and energy metabolism.
2. What is required in a balanced diet and what effect do they have?
3. What is the role of vitamins in the body (deficiencies and overdoses)?
4. What are the common causes of fatigue?
5. Why is in-depth history taking and examination important?



## Scenario 3

### PBL Group 23

#### *Main Issues*

Mother pressured her into consulting doctor

Feels pressured into being a certain weight

Exam pressure – worries about future

Vegan diet

Teenage consultations and autonomy issues

Teenage pregnancies – young mothers

Diet diary

Eating disorders

#### *Questions*

1. What influences normal eating habits, what makes us hungry?
2. What is a Vegan diet and what are the problems associated with it?
3. What are the causes and symptoms of the main eating disorders?
4. What are the main possible influences on Aileen's eating disorder?
5. How common are the eating disorders and how are they treated and diagnosed?
6. What are the main issues concerning teenage consultation?



## PBL Group 25

### *Main Issues*

Eating disorders

Veganism and dieting deficiencies of vegans

Diet

Appetite

### *Questions*

1. What is the neural mechanism controlling diet?
2. Discuss the common types of eating disorders.
3. What are the pros and cons of veganism?
4. Why do we really need a healthy diet? (carbohydrates, amino acids)



## Scenario 4

### PBL Group 25

#### *Main Issues*

Influence of drugs

Addiction

Recreational drugs

Role of police surgeon

Alcohol

Drugs – difference, legality

Effect of drugs

#### *Questions*

1. What are recreational drugs and what are their effects?
2. What are the social causes of drug abuse?
3. Define and discuss addiction in relation to recreational drugs.
4. Discuss abuse of common therapeutic drugs.
5. Describe the role of the police surgeon.

### PBL Group 27

#### *Main issues*

Drugs – types, consequences, behaviour, signs

Police surgeon – social repercussions/shop-owner

Education – who does it

#### *Questions*

1. Types of drugs commonly abused
2. Physical signs the doctor would see and interpret
3. What are the behavioural signs of use and brain chemistry?
4. Short and long term consequences / addiction / dependence.
5. Societal level / Family level / effects and response.



## Scenario 5

### PBL Group 23

#### *Main Issues*

GPASS System

Smoking / Alcohol abuse

Trends in abuse

Social classes

Drinking habits

Trends in addiction

Perceptions of 'what is a problem'

Impacts on health; social smoking /  
drinking

#### *Questions*

1. What is GPASS?
2. What are the physical effects of smoking?
3. What is the physiology of addiction to smoking?
4. What are the patterns of cigarette use in society?
5. What are the short and long term effects of alcohol?
6. What is the physiology of alcohol addiction?
7. What are the patterns of alcohol addiction?
8. What are the drugs for smoking and alcohol addiction?
9. Define social class and relate to addictions.



## **PBL Group 31**

### ***Main Issues***

Smoking

Drinking – units/wk

General addictions

Social class – reaction to addiction,  
definition

Social / Psychological / Physical signs  
of addiction

Impact of addiction on general health

National statistics

### ***Questions***

1. What are the physical effects of smoking and drinking?
2. Why do people smoke and drink (and who does it)?
3. What is societies stance on smoking and drinking?
4. Describe the classification of social classes with relation to addiction.



## Scenario 6

### PBL Group 29

#### *Main Issues*

Cough

Long term smoking

Antibiotic

Chest examination

Causes of cough

Smoking related diseases

Age

Anatomy of lung

#### *Questions*

1. Describe the anatomy of the lungs at a cellular level (healthy and diseased).
2. What is the mechanism of the cough reflex?
3. What are chronic bronchitis and emphysema and how do they differ?
4. What is the relation between smoking and CHD?
5. Why does it take so long for clinical signs of COPD to appear?

### PBL Group 28

#### *Main Issues*

Coughing – examination

Family

Smoking – economics, duration, amount

Chest infection/problems – bronchitis, emphysema, asthma

Antibiotics – kill/stop growth, resistance

#### *Questions*

1. How does smoking cause respiratory disease, what are they?
2. Explain coughing mechanism.
3. Revise antibiotics
4. What signs should be looked for in this case?
5. How does Mr. Johnstone's smoking affect his family?



## Scenario 7

### PBL Group 28

#### *Main issues*

Asthma – stress, loss of sleep,  
restricted activity

Inhalers – loss of sleep, nebulisers,  
oxygen relief

Missed diagnosis – why

Refusing treatment – rebellious, why,  
how to communicate

Epidemiology – young, older, genetic,  
grow out of it

Causes (triggers) – genetic, smoking,  
air pollution, social class, climate,  
allergy, dust mites

#### *Questions*

1. What is asthma?
2. Causes, trigger of attack
3. Treatment and management
4. Why is asthma undiagnosed?
5. Epidemiology and why increasing
6. What if a child refuses treatment?



**PBL Group 30**

***Main Issues***

Asthma diagnosis

Asthma in children

Consent

Causes and treatment

Prevalence

***Questions***

1. What is asthma and explain its symptoms?
2. Investigate possible causes of asthma and triggers.
3. How is asthma diagnosed?
4. How is asthma treated, in the short and the long run?
5. Investigate prevalence of asthma in children.



## Scenario 8

### PBL Group 24

#### *Main Issues*

Angina – defined, symptoms, treatment (bypass, aspirin), causes (smoking, diet, exercise, genetics)

Atherosclerosis – defined, significance, treatment

CHD – prevalence (esp. Scotland), defined, types, symptoms

#### *Questions*

1. Discuss coronary heart disease: a) definition; b) signs, symptoms, pathology; c) causes; d) prevalence
2. Discuss angina: a) definition; b) pathology; c) management and treatment

### PBL Group 28

#### *Main Issues*

Angina – definition, causes, treatment

Exertion

Types of pain – why radiating

Related disorders

How is it related to heart attacks

What is heart attack, myocardial infarction

#### *Questions*

1. What constitutes heart disease related to smoking (include myocardial infarction)?
2. What is angina (causes, treatment, management)?
3. How and why does the pain radiate?
4. How does lifestyle affect heart disease (include exercise)?



## Scenario 9

### PBL Group 25

#### *Main Issues*

Cholesterol levels

Risk factors

Heart disease

Treatment

Diet

Lifestyle changes

Tests

#### *Questions*

1. What is cholesterol and how does it relate to heart disease?
2. Discuss treatments for heart disease.
3. How does diet affect heart disease?
4. How does lifestyle affect heart disease and treatment?
5. What diagnostic tests are there for heart disease (invasive & noninvasive)?



## **PBL Group 28**

### ***Main Issues***

Cholesterol levels and their  
association to diet and metabolism

Bypass surgery, procedure and  
indications

Risk factors

Medication

Investigations

Lifestyle changes

### ***Questions***

1. What is the function of cholesterol, when is it harmful?
2. What are lipids and what is their function related to CHD?
3. What is blood supply of heart?
4. Indications for surgery and what surgery?
5. How can risk factors be reduced, individually and socially?
6. Revise ECG.
7. Costs of CHD and dealing with it?
8. What is an anti-oxidant and why are they important in diet?



## Scenario 10

### PBL Group 23

#### *Main Issues*

re – CHD

Individuals

Population

Prevention – 1y, 2y, 3y

Monitoring and audit

Social and economic factors

Population interventions and social policies

Care – 1y, 2y, 3y

#### *Questions*

1. Define 1y, 2y, 3y prevention.  
Relate this to CHD.
2. What are the processes involved in collating information for reports such as SNAP?
3. What are the current policies related to CHD prevention?
4. Discuss the success of previous campaigns (i.e. Finland) and what can be done here in the future?
5. Compare and contrast prevention of CHD at the individual and population level.



## **PBL Group26**

### ***Main Issues***

Levels of healthcare

Management of CHD

Social policies & population based  
intervention

Rehabilitation & secondary prevention

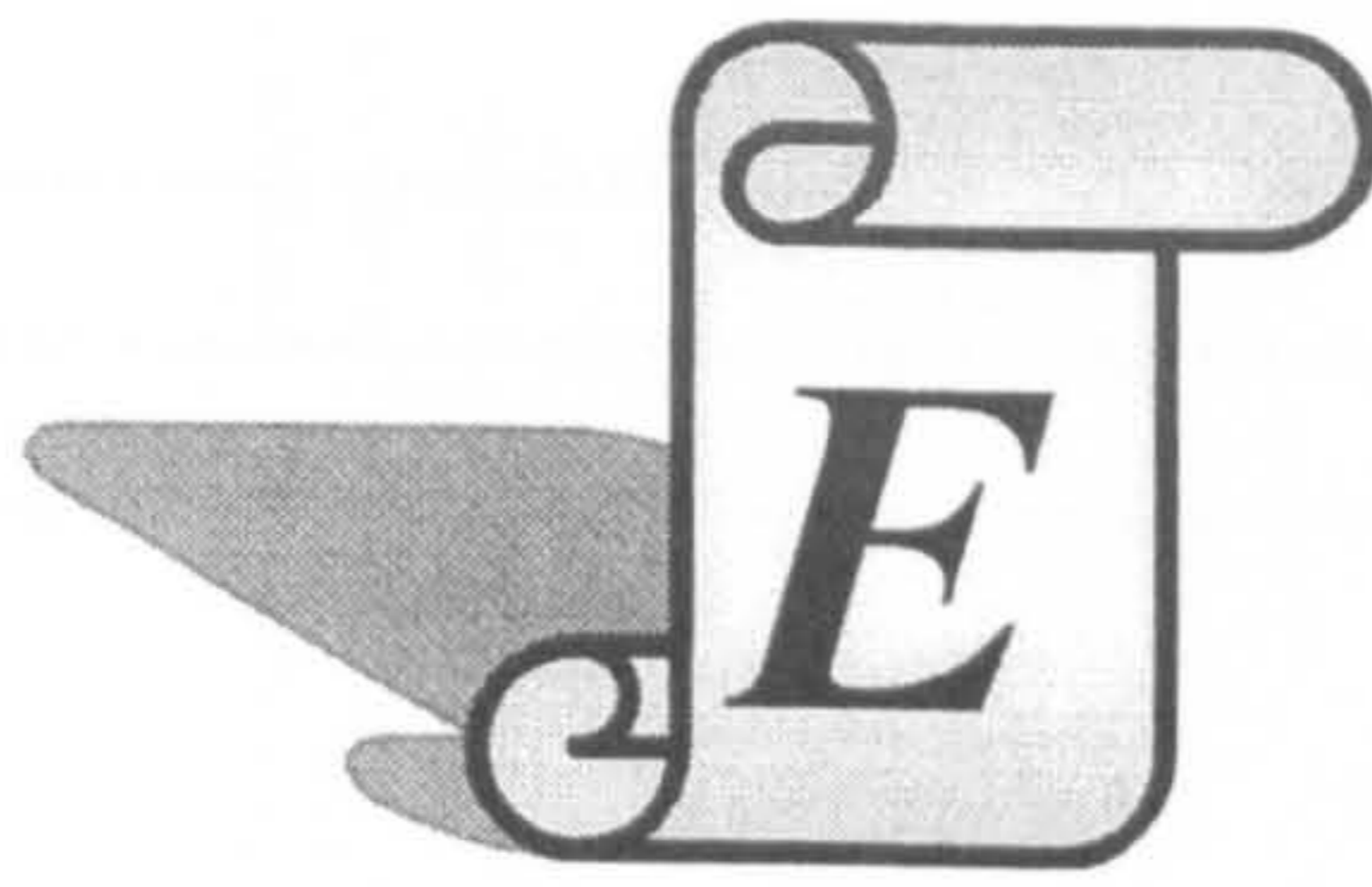
Research & monitoring

Social & economic circumstances

### ***Questions***

1. Explore the 1<sup>o</sup>, 2<sup>o</sup> & 3<sup>o</sup> levels of health care related to CHD.
2. How is CHD managed at each level?
3. What social policies can reduce the risk of CHD?
4. Why target the whole population to reduce the risk of CHD?
5. Define the levels of prevention and relate them to CHD.
6. What social and economic circumstances affect the risk of CHD?
7. What social and economic interventions can cause a decline in the risk of CHD?





## *Appendix E*

### *Collected Concept Maps*

#### ***Scenario 1***

<i>Student # 240</i> .....	<i>E1</i>
<i>Student # 243</i> .....	<i>E2</i>
<i>Student # 261</i> .....	<i>E3</i>

#### ***Scenario 2***

<i>Student # 243</i> .....	<i>E4</i>
<i>Student # 274</i> .....	<i>E5</i>

#### ***Scenario 3***

<i>Student # 210</i> .....	<i>E6</i>
<i>Student # 240</i> .....	<i>E7</i>
<i>Student # 262</i> .....	<i>E8</i>
<i>Student # 269</i> .....	<i>E9</i>
<i>Student # 274</i> .....	<i>E10</i>
<i>Student # 278</i> .....	<i>E11</i>

#### ***Scenario 4***

<i>Student # 202</i> .....	<i>E12</i>
<i>Student # 209</i> .....	<i>E13</i>
<i>Student # 210</i> .....	<i>E14</i>
<i>Student # 234</i> .....	<i>E15</i>
<i>Student # 274</i> .....	<i>E16</i>
<i>Student # 278</i> .....	<i>E17</i>



**Scenario 5**

*Student # 210*.....E18  
*Student # 234*.....E19  
*Student # 245*.....E20

**Scenario 6**

*Student # 210*.....E21

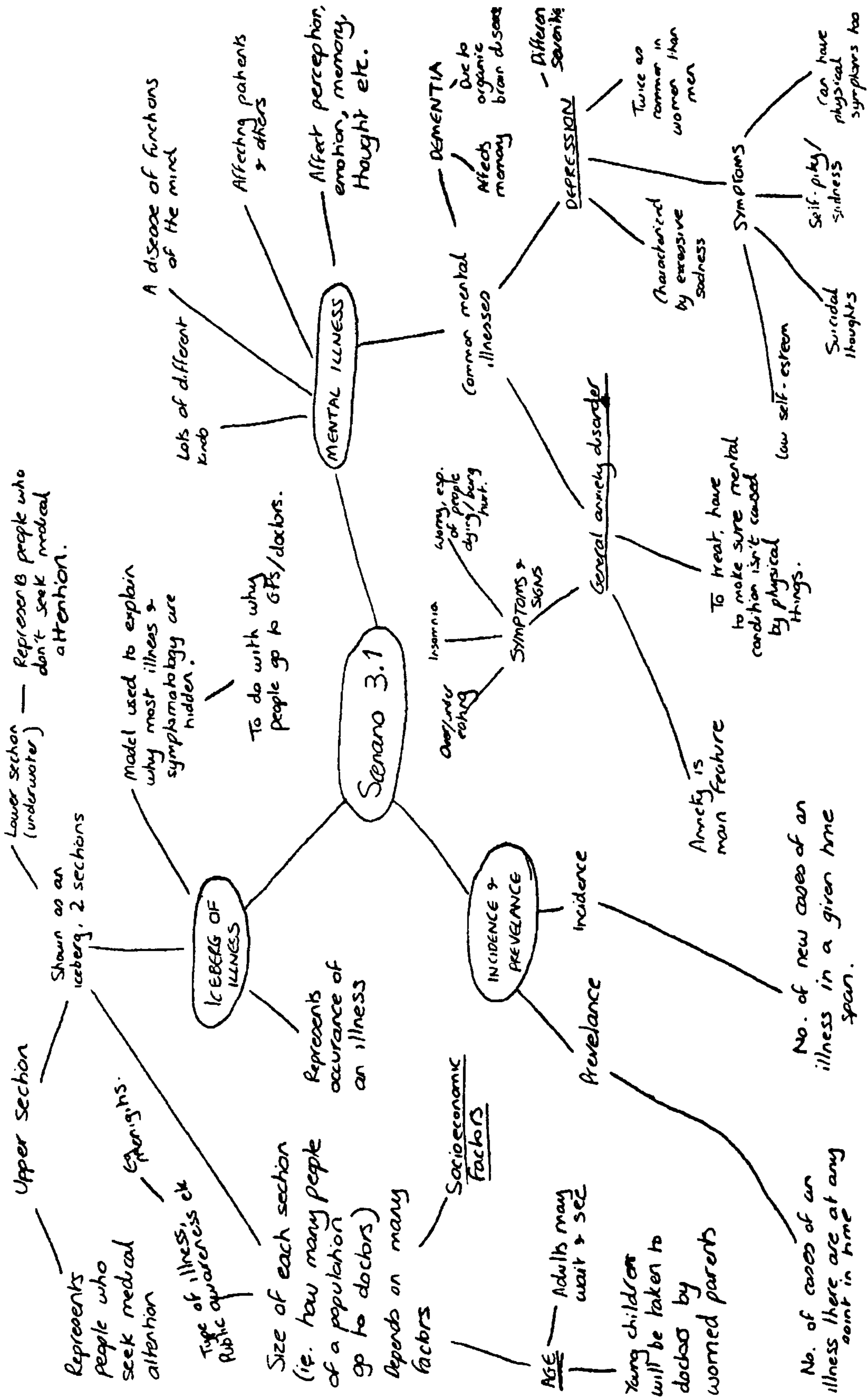
**Scenario 8**

*Student # 210*.....E22  
*Student # 217*.....E23

**Scenario 9**

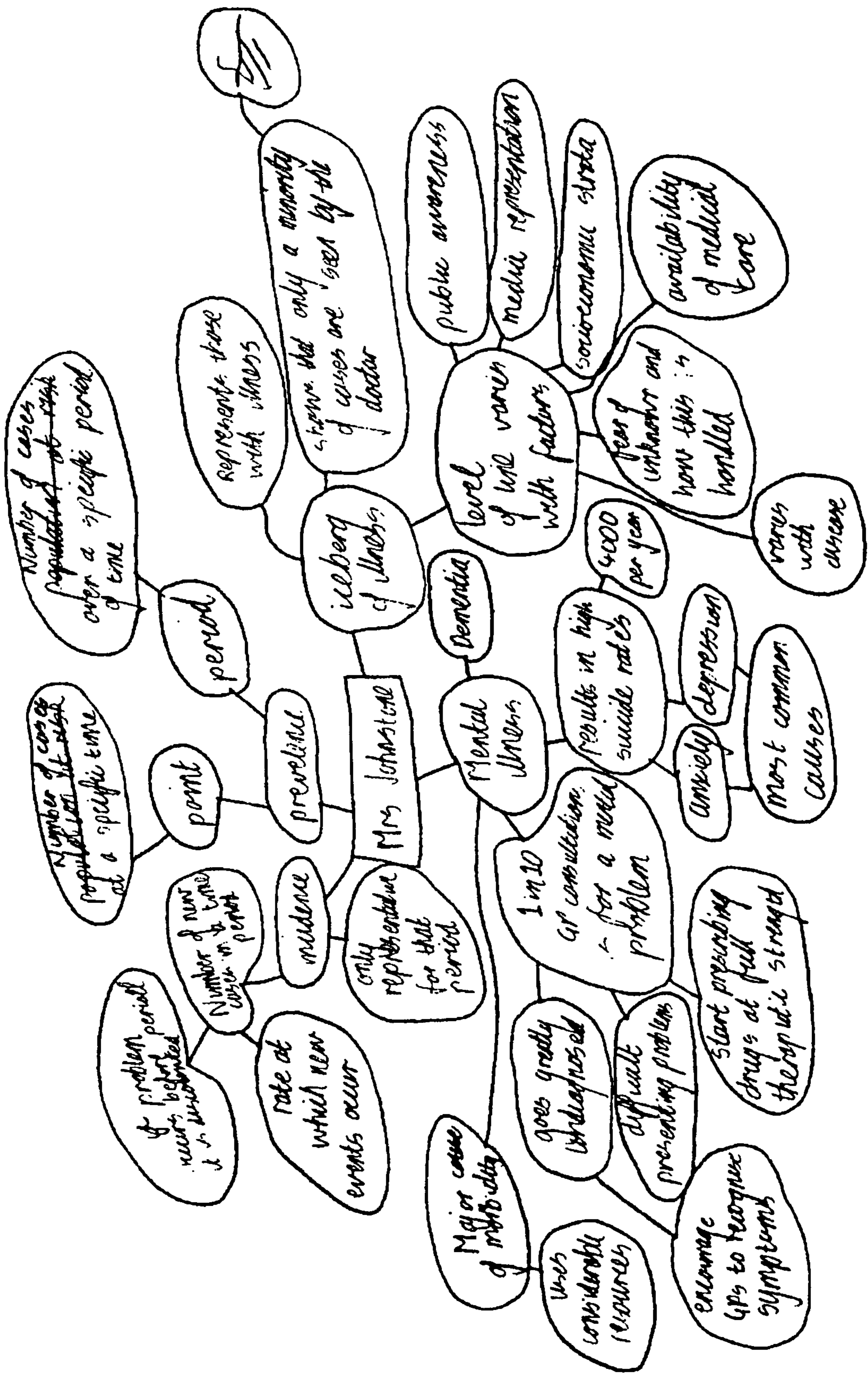
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*Student # 222*.....E25  
*Student # 237*.....E26  
*Student # 245*.....E27



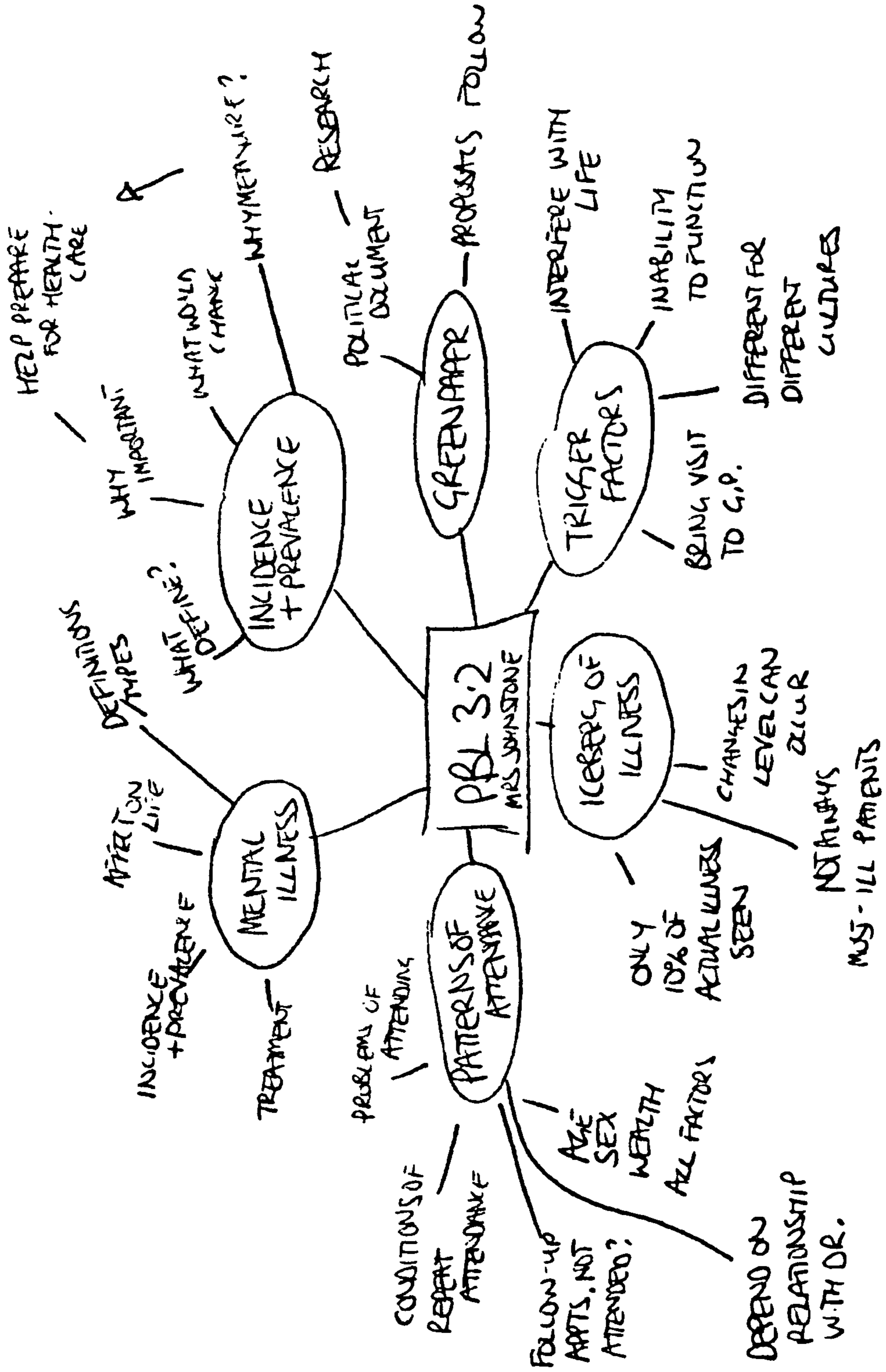


Student 240 - Scenario 1

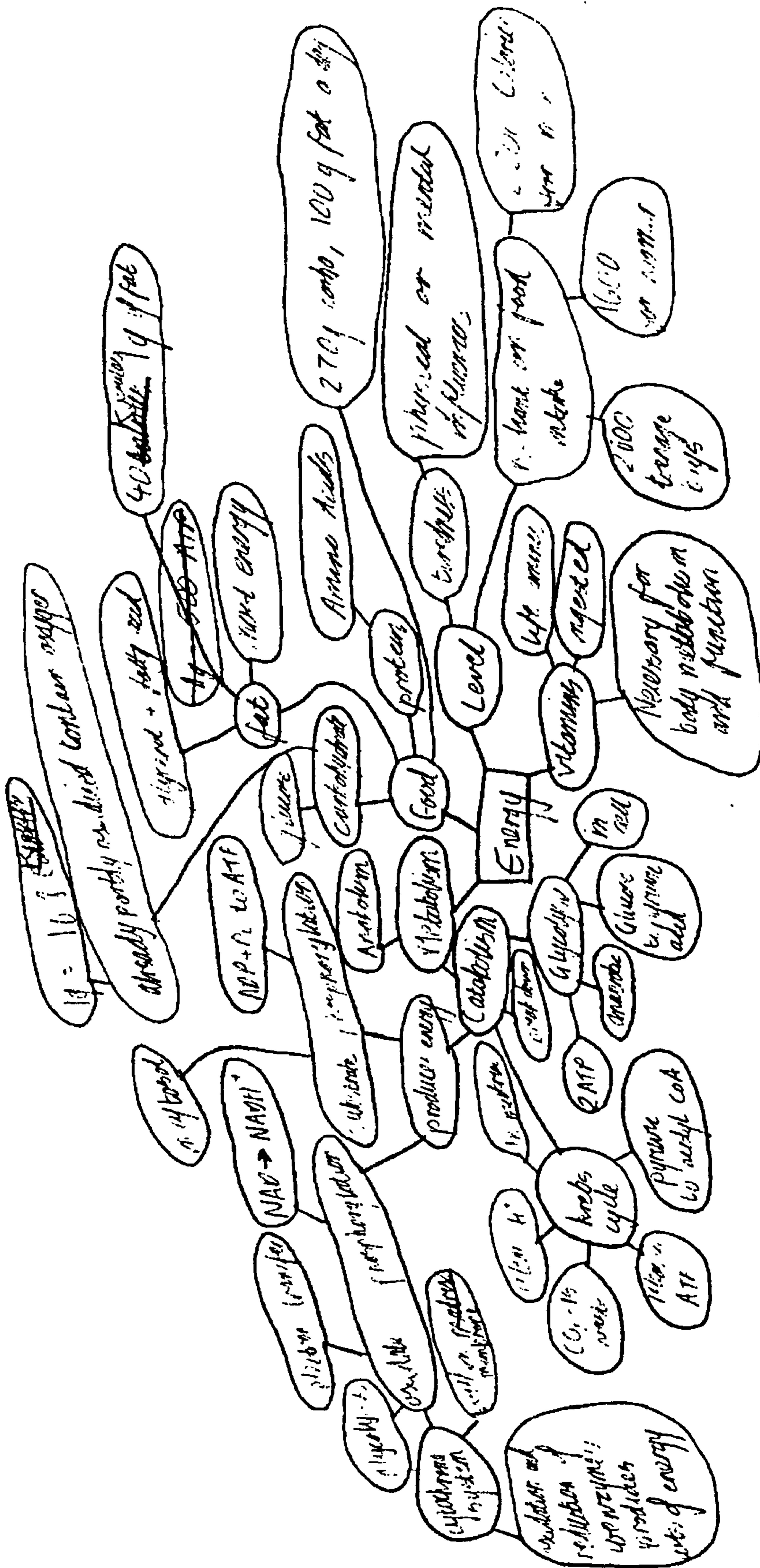






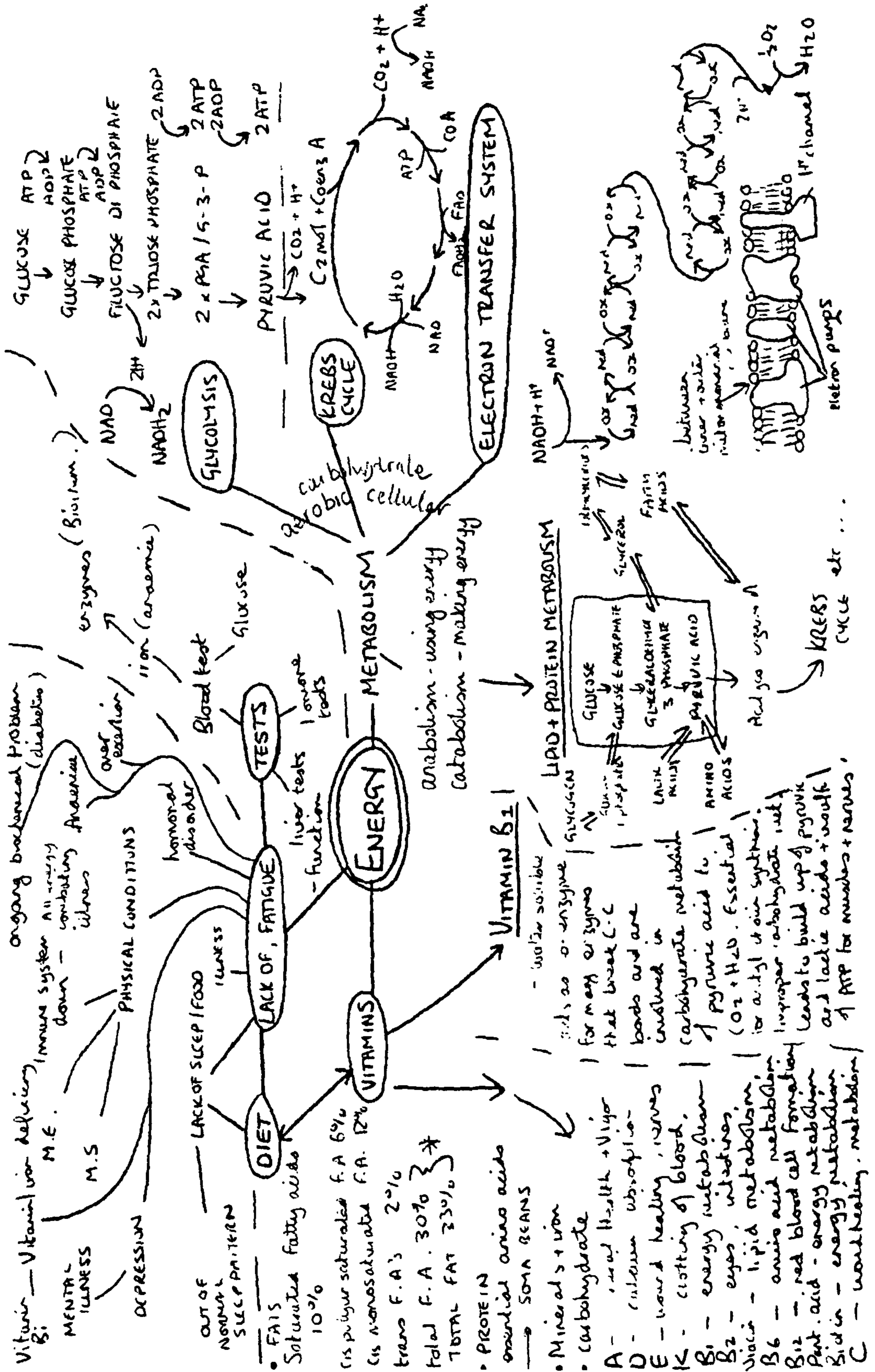






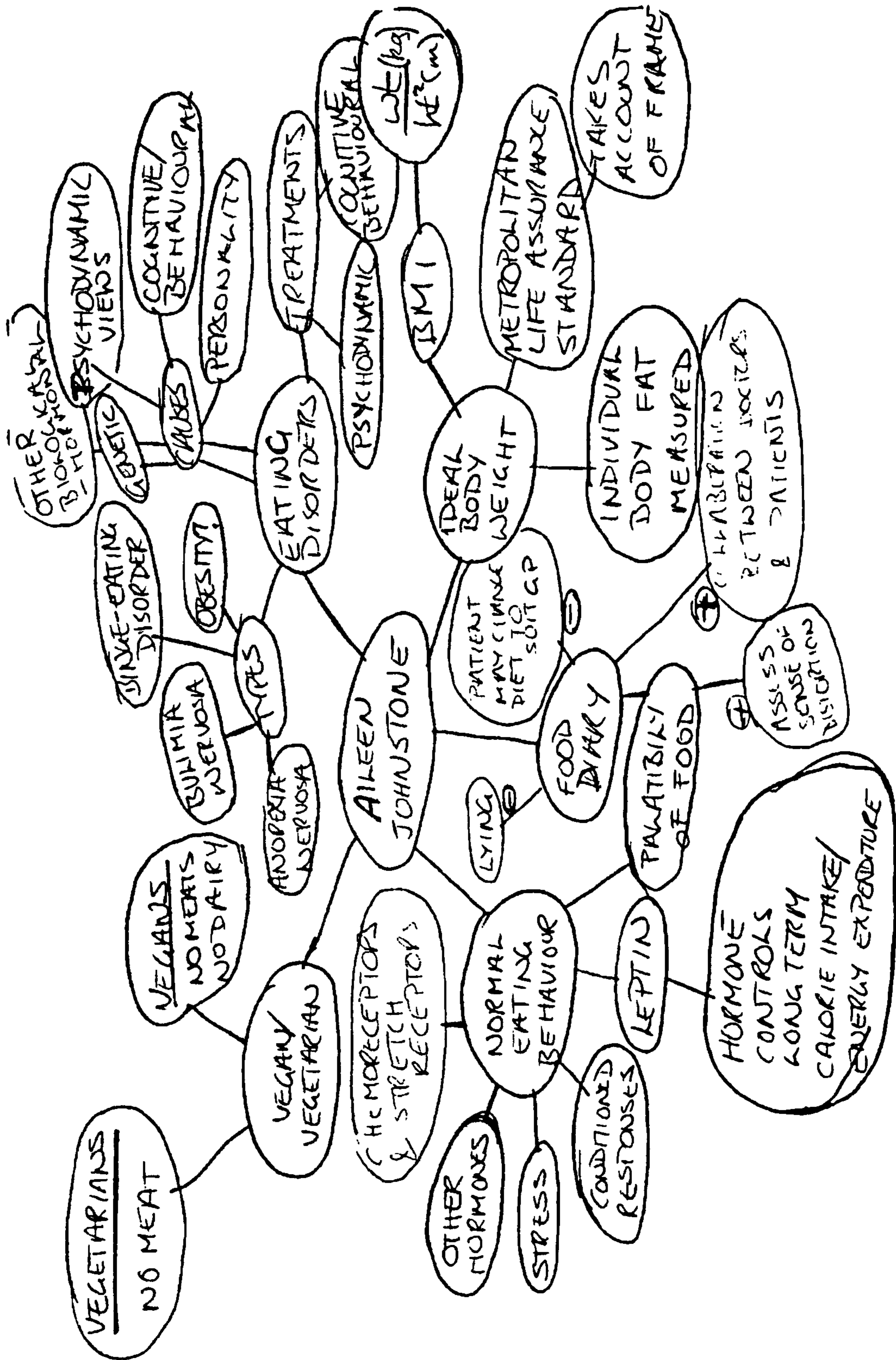
Student 243 – Scenario 2





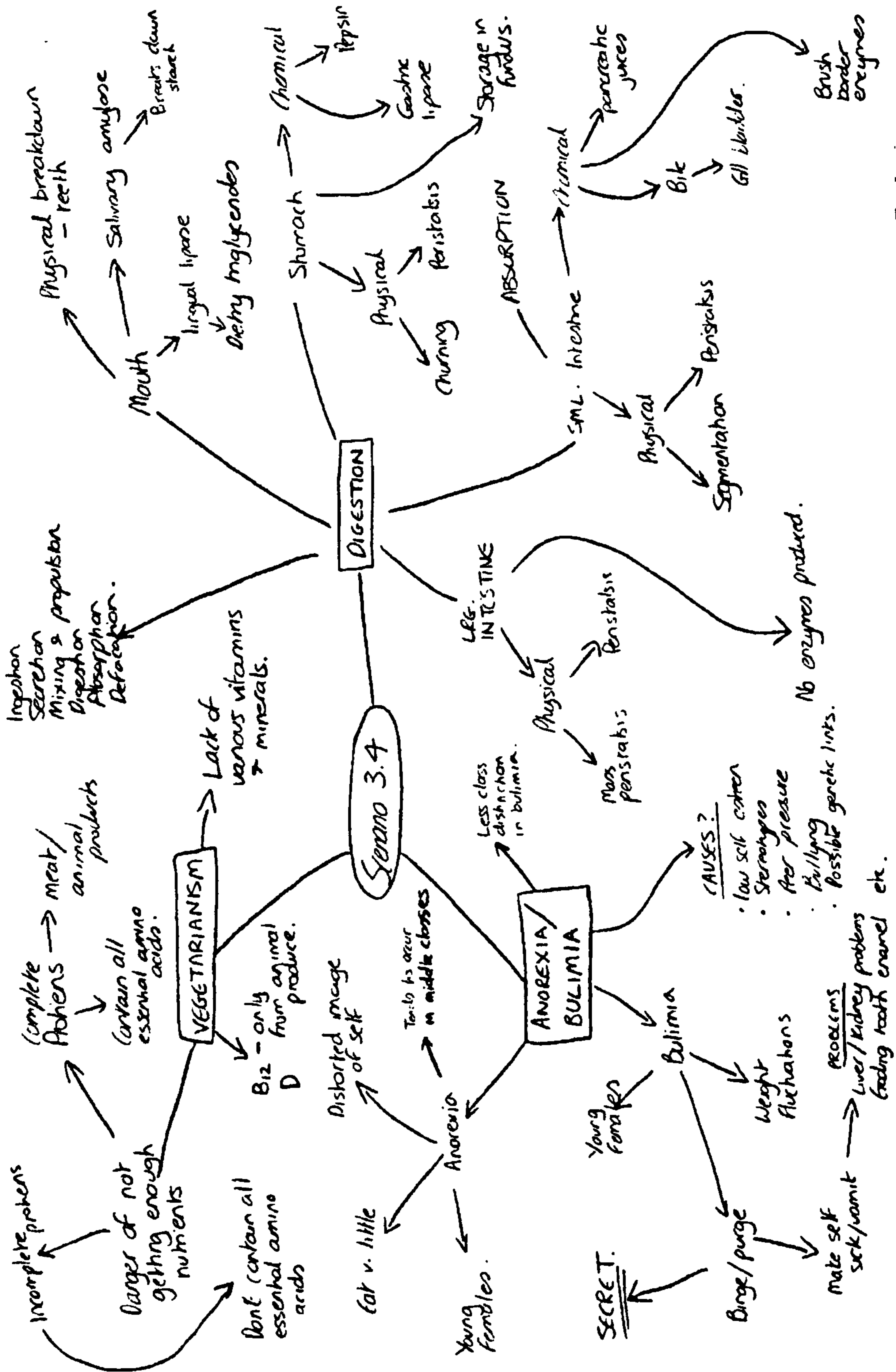
Student 274 - Scenario 2





Student 210 – Scenario 3





Student 240 - Scenario 3













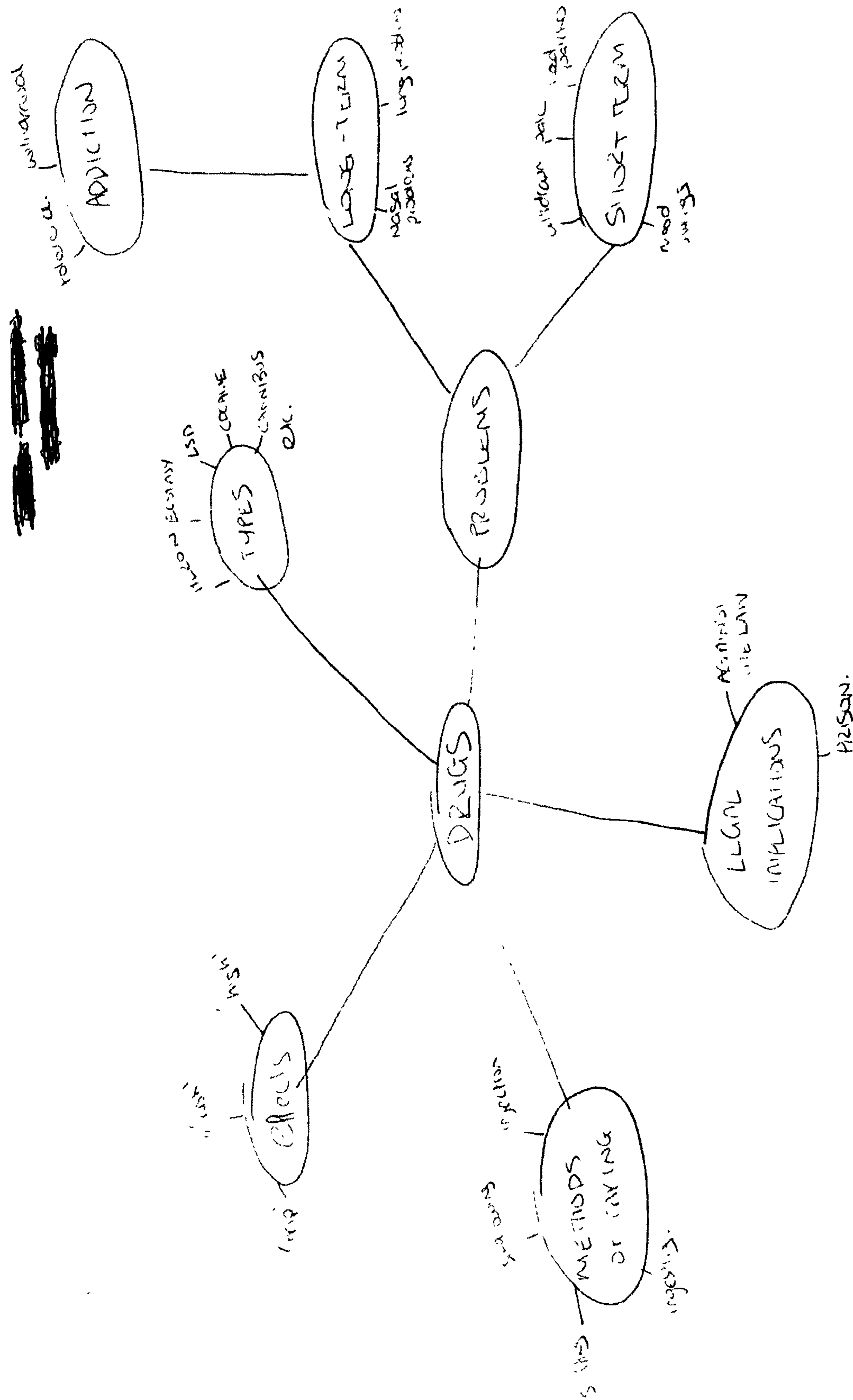




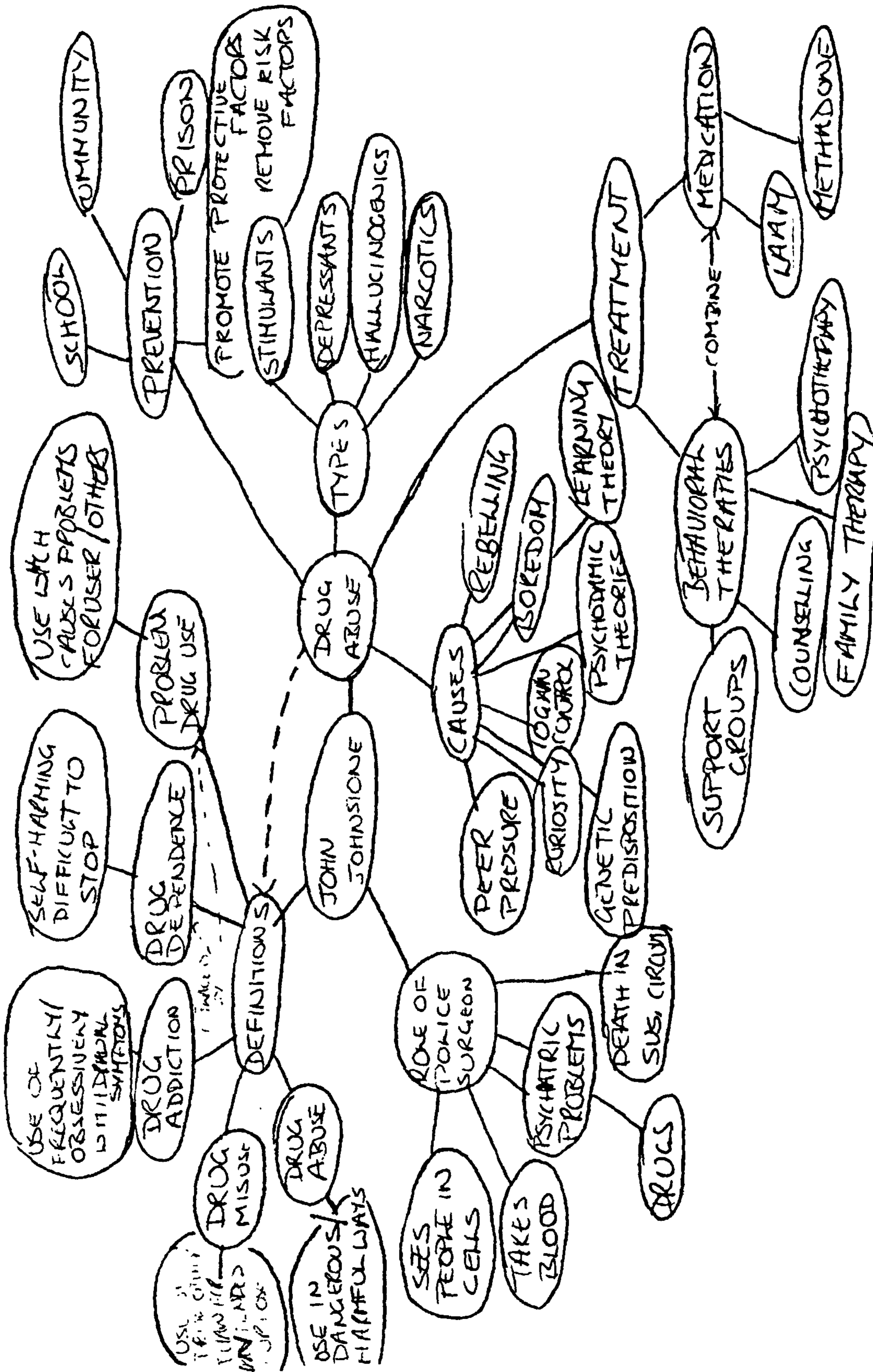




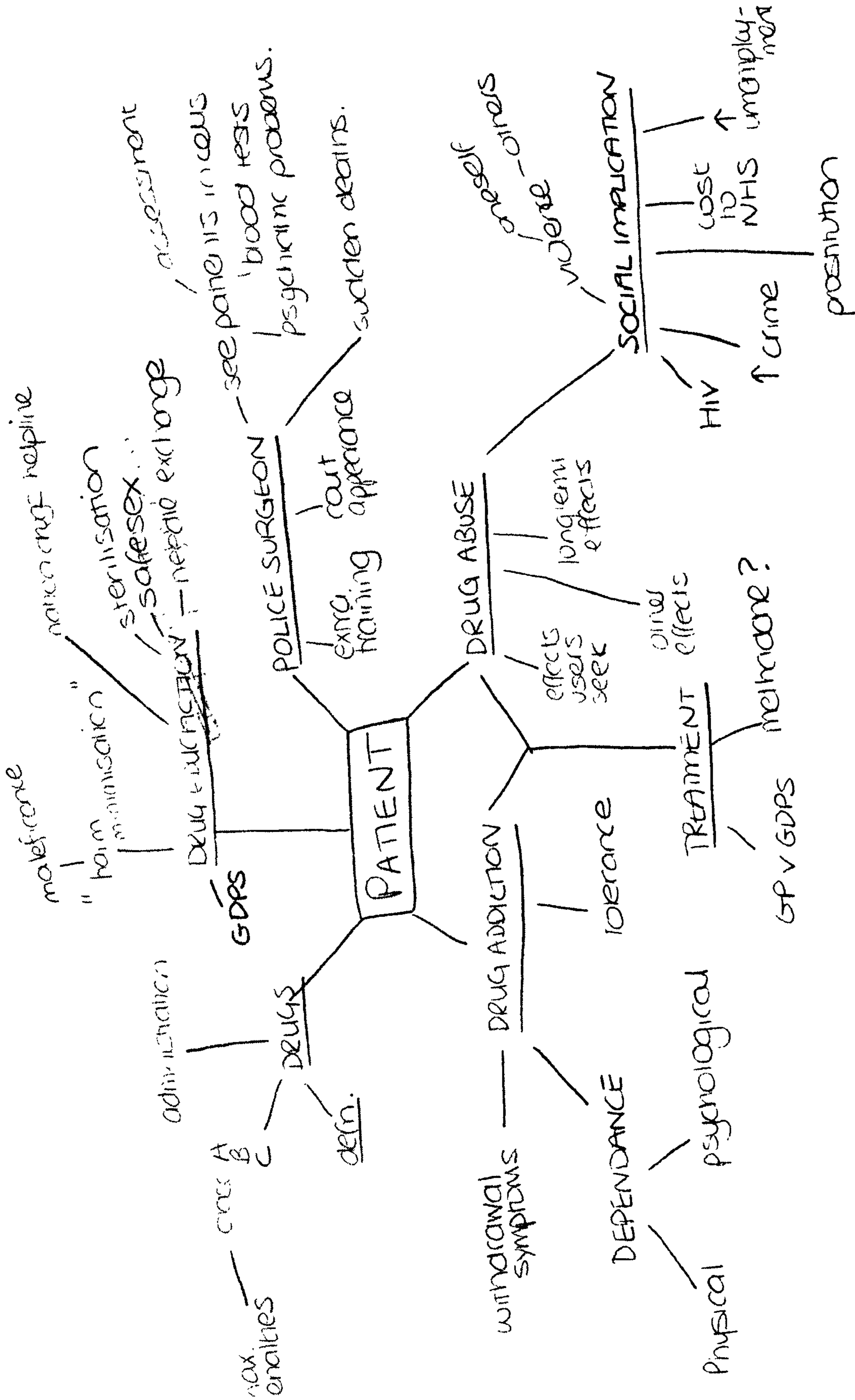




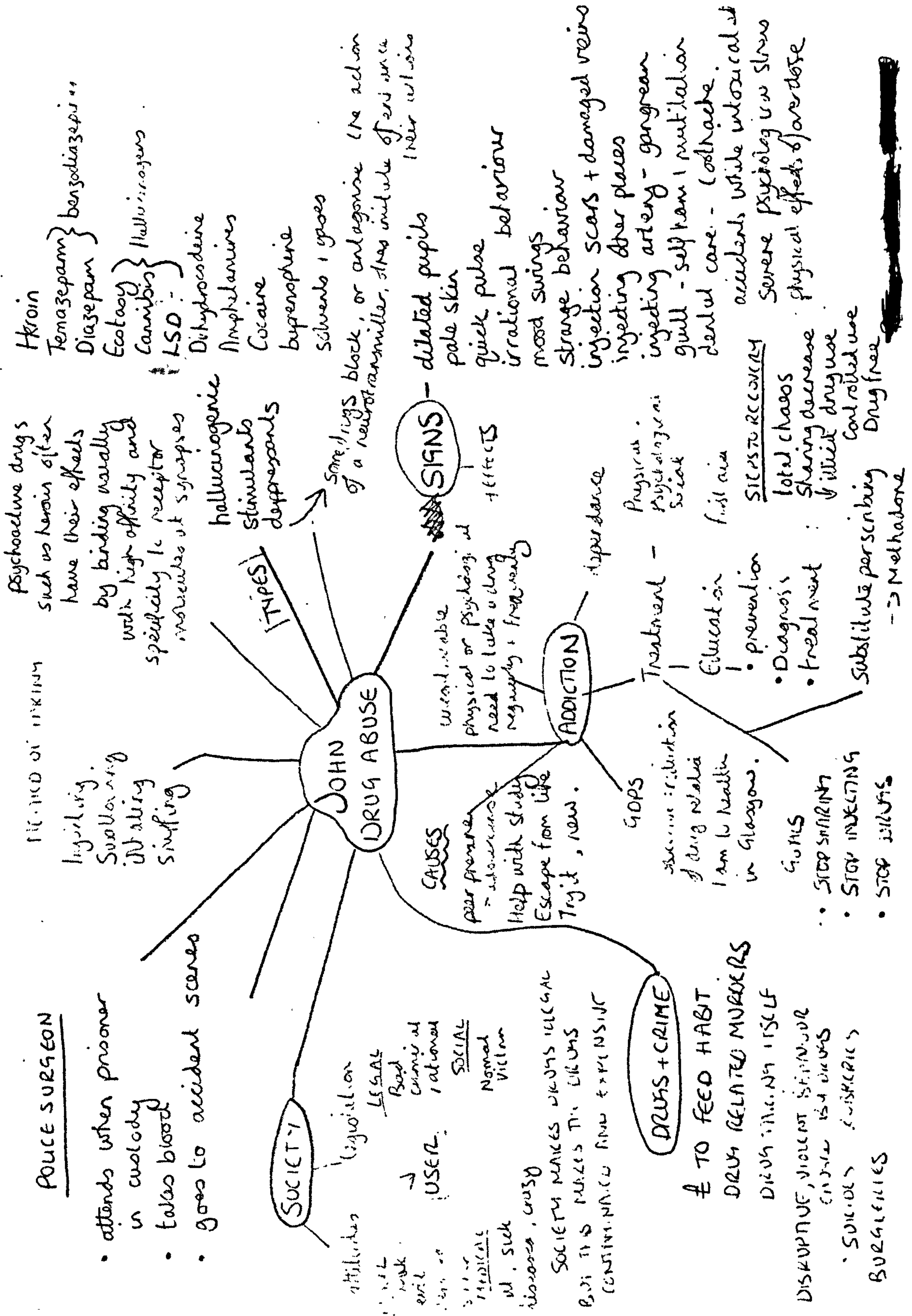


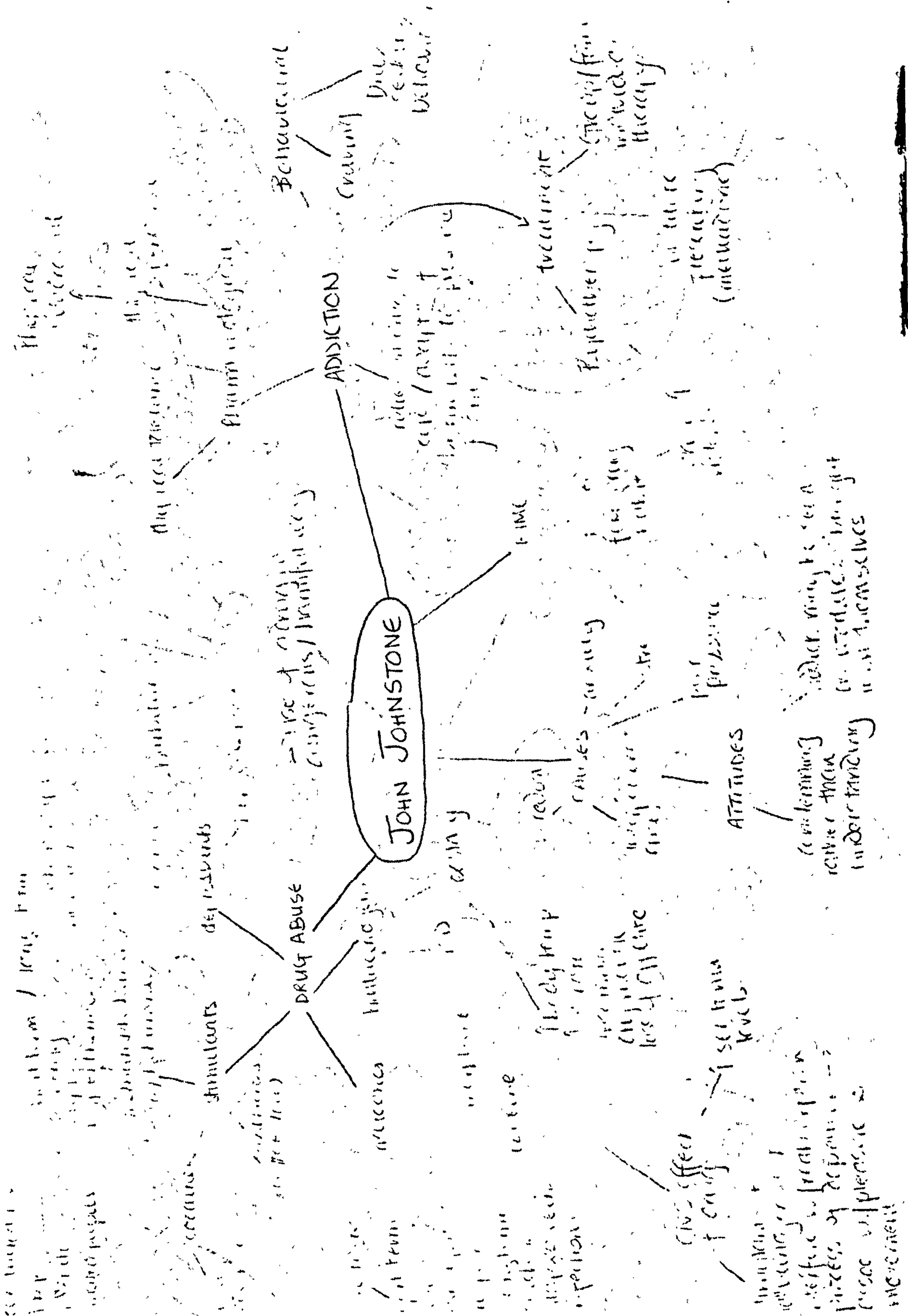


Student 210 – Scenario 4

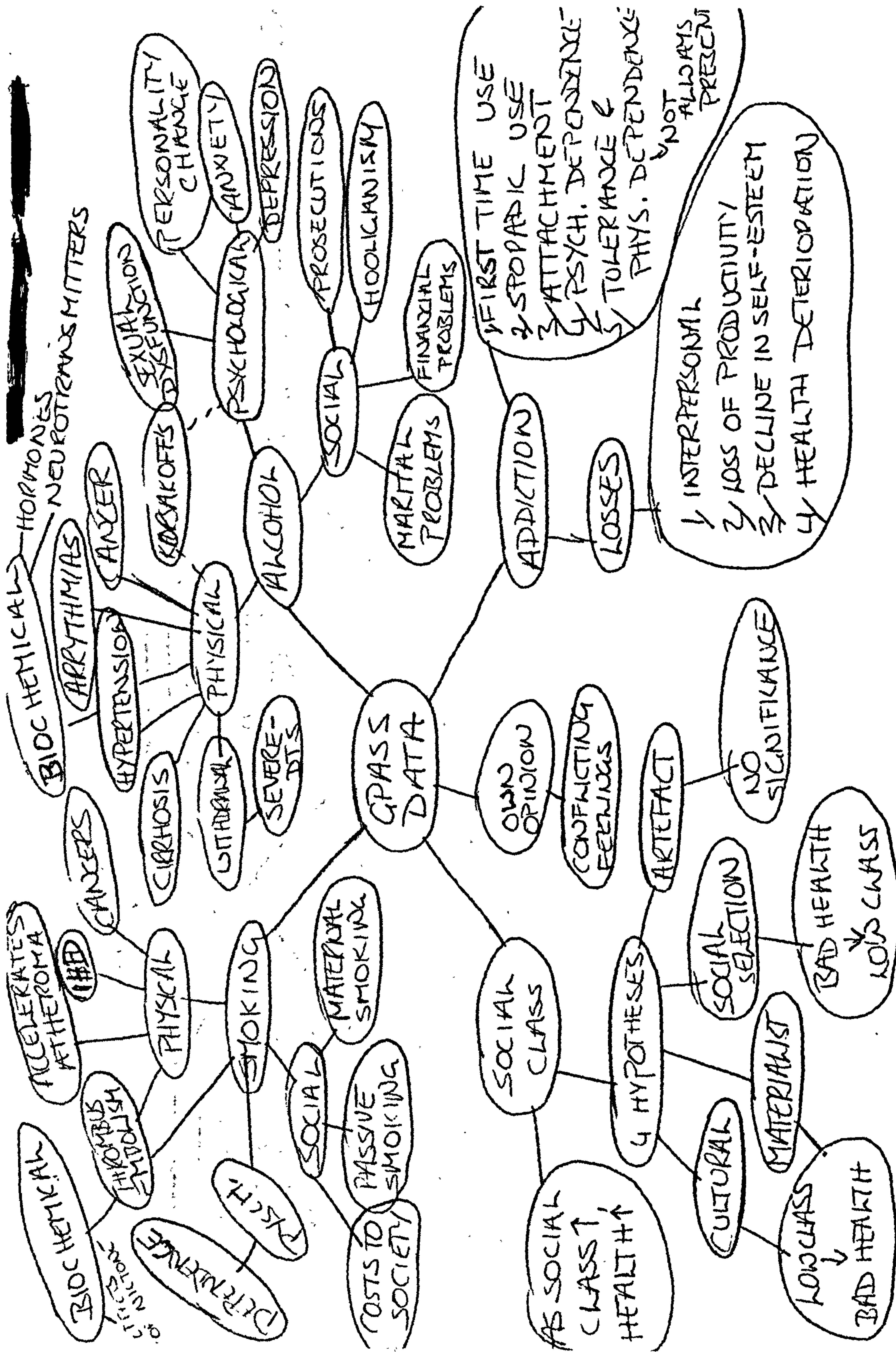


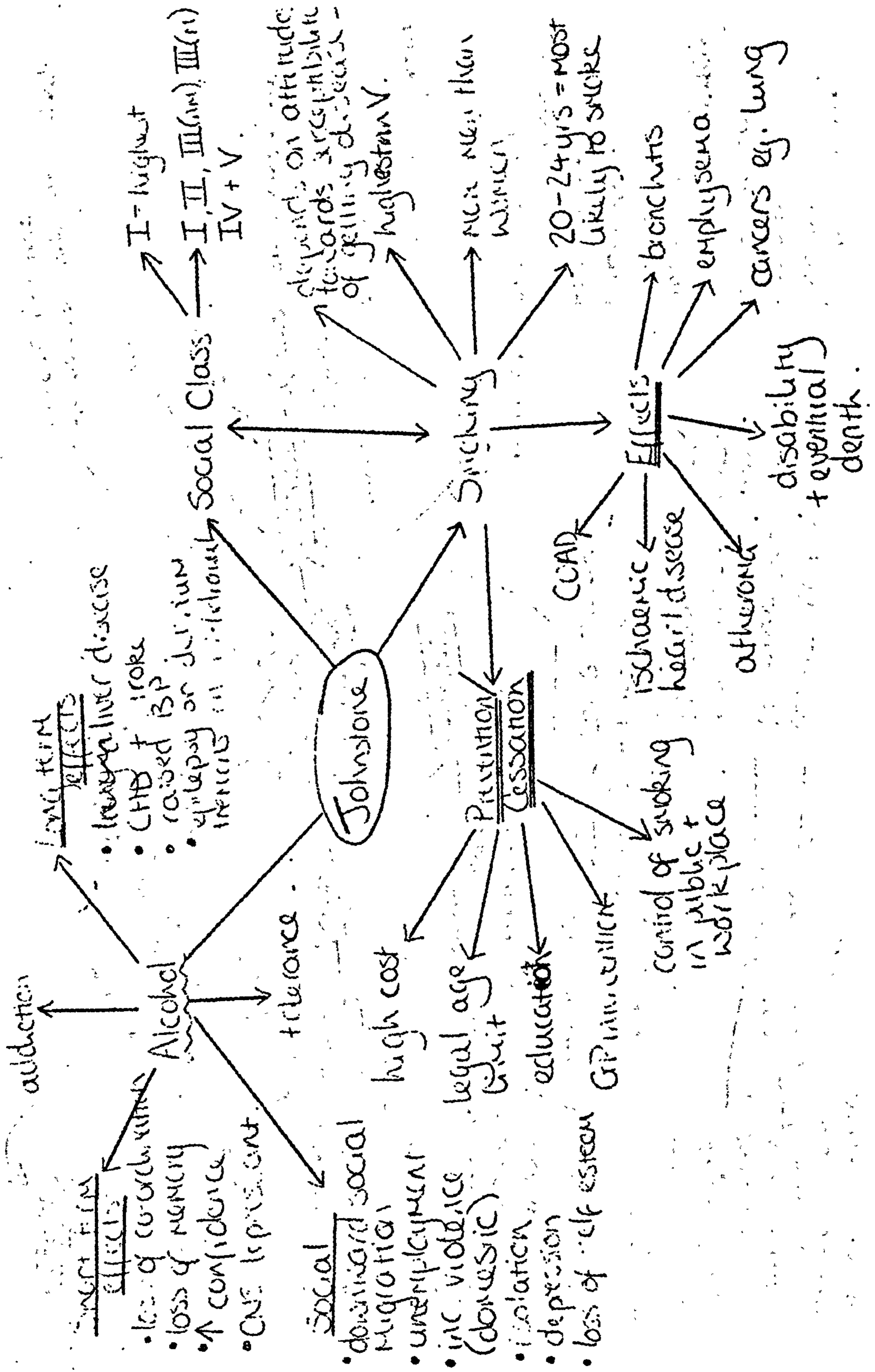






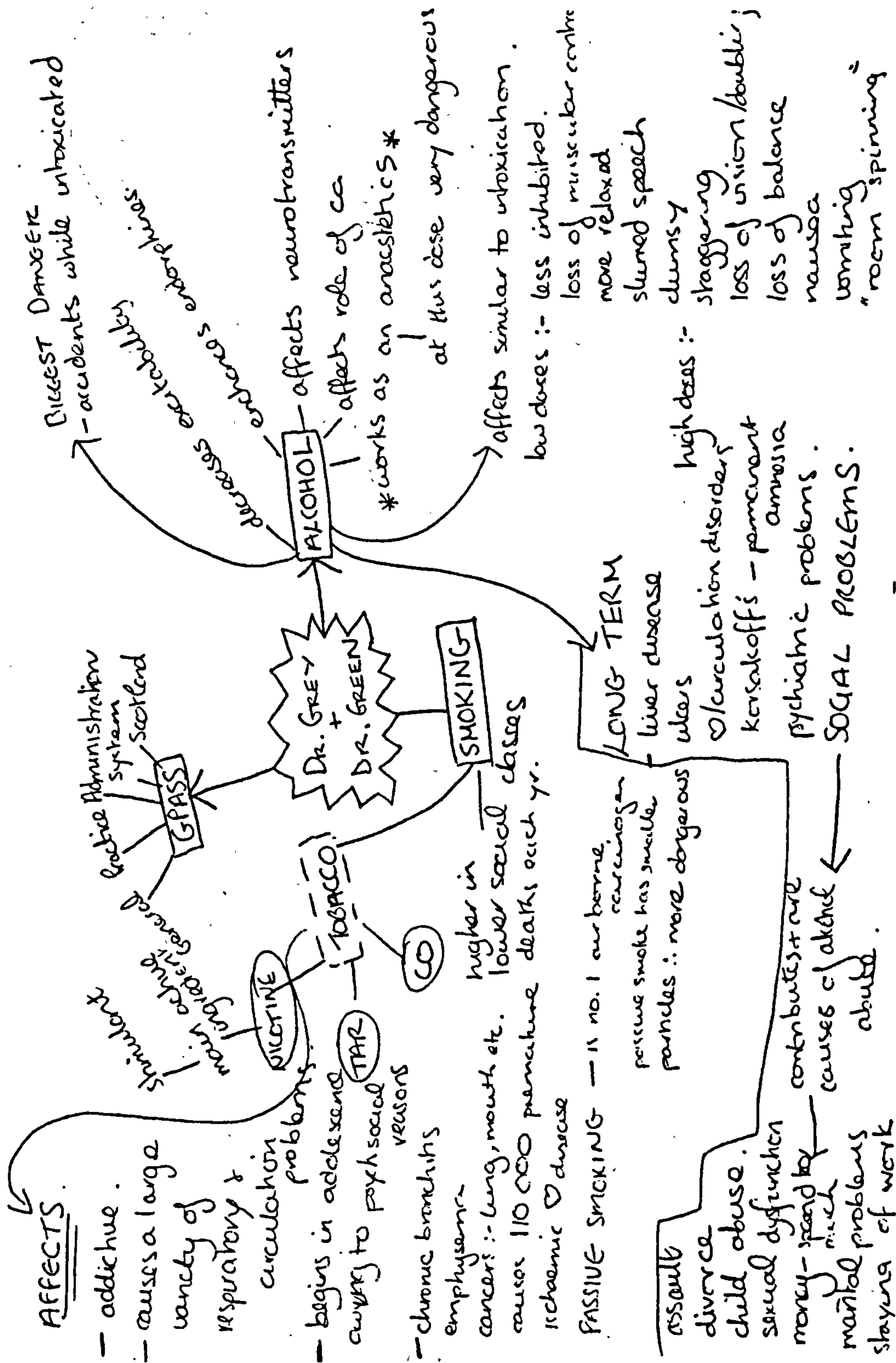




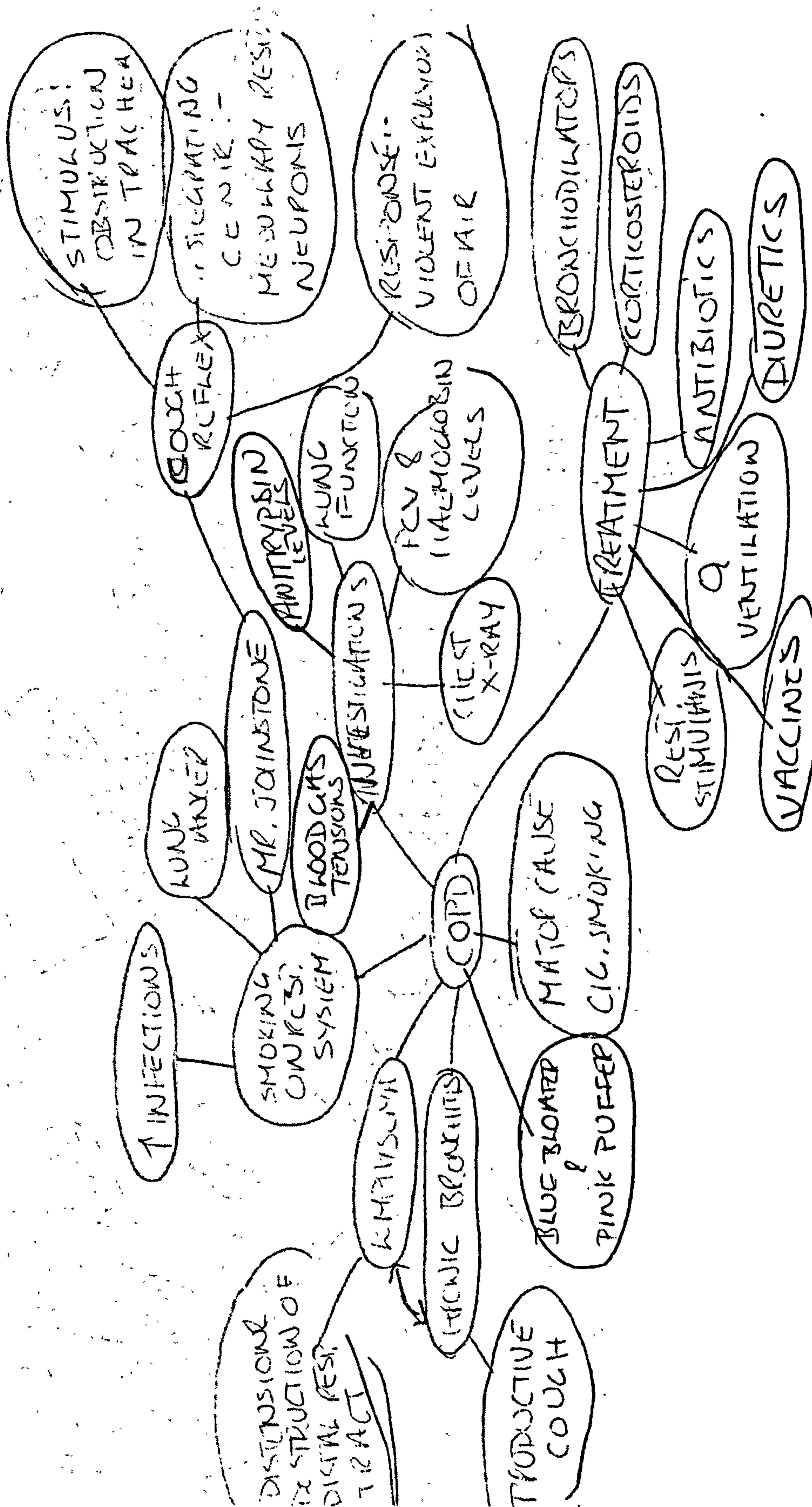


Student 234 - Scenario 5

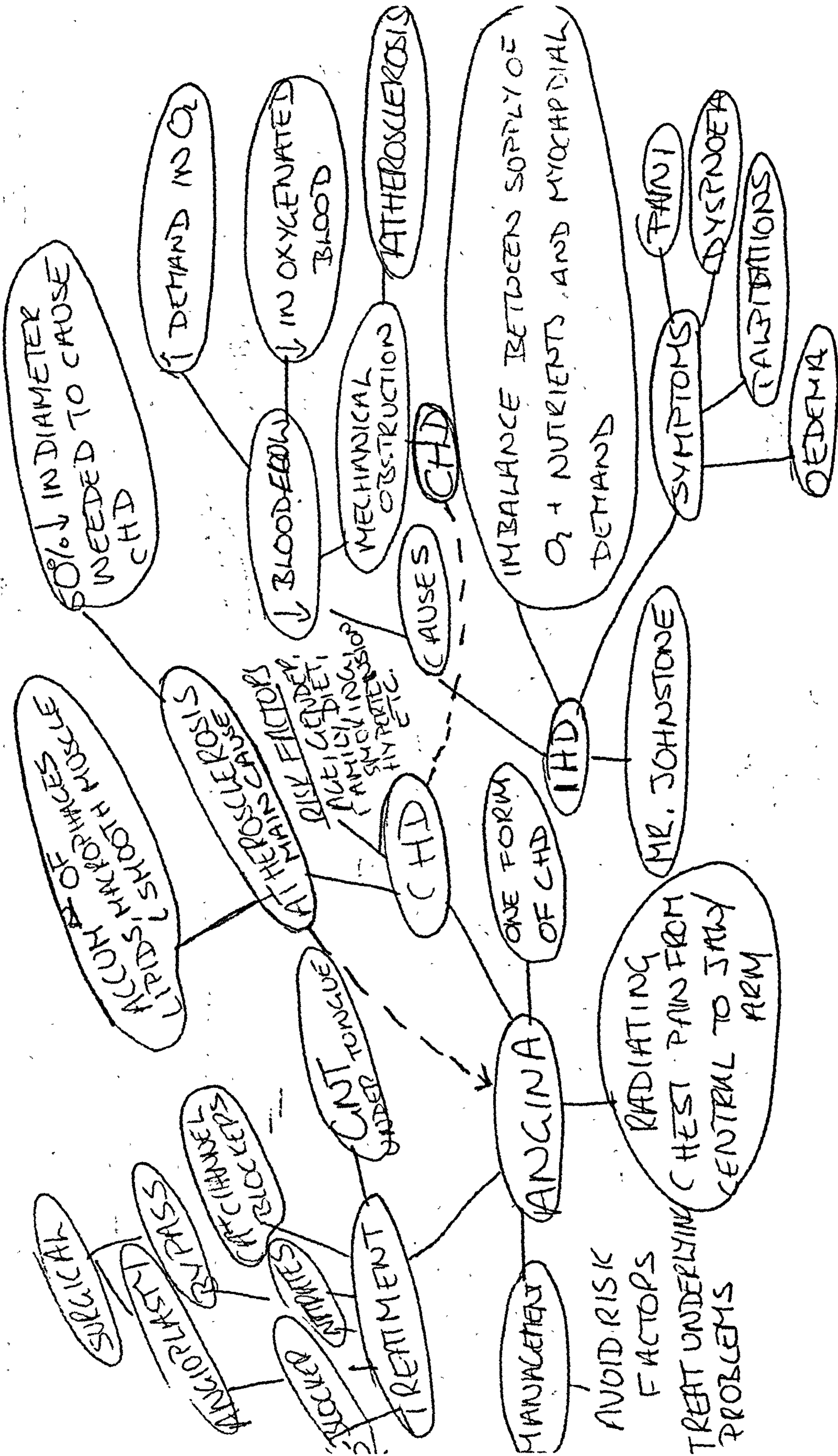


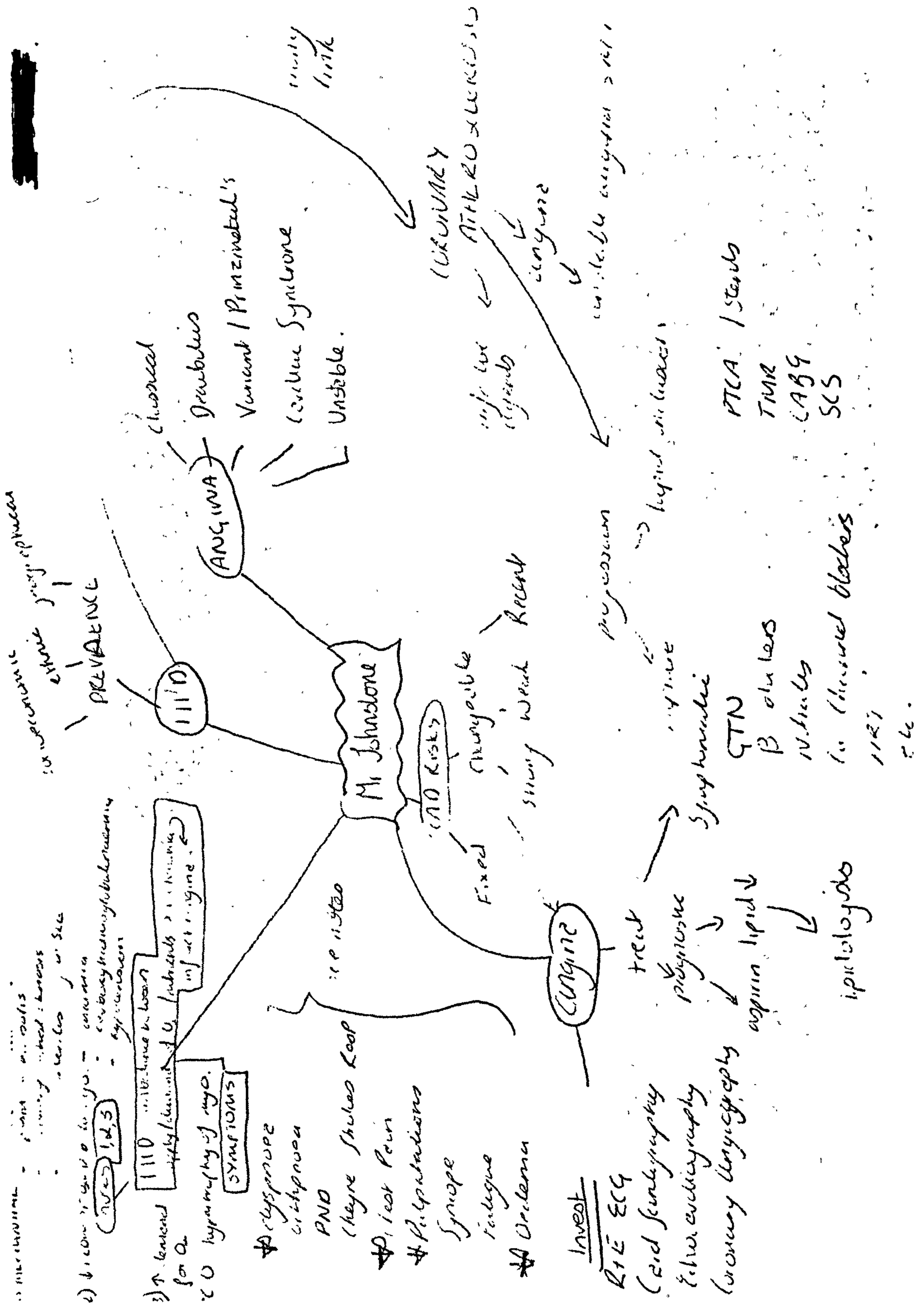


Student 245 - Scenario 5

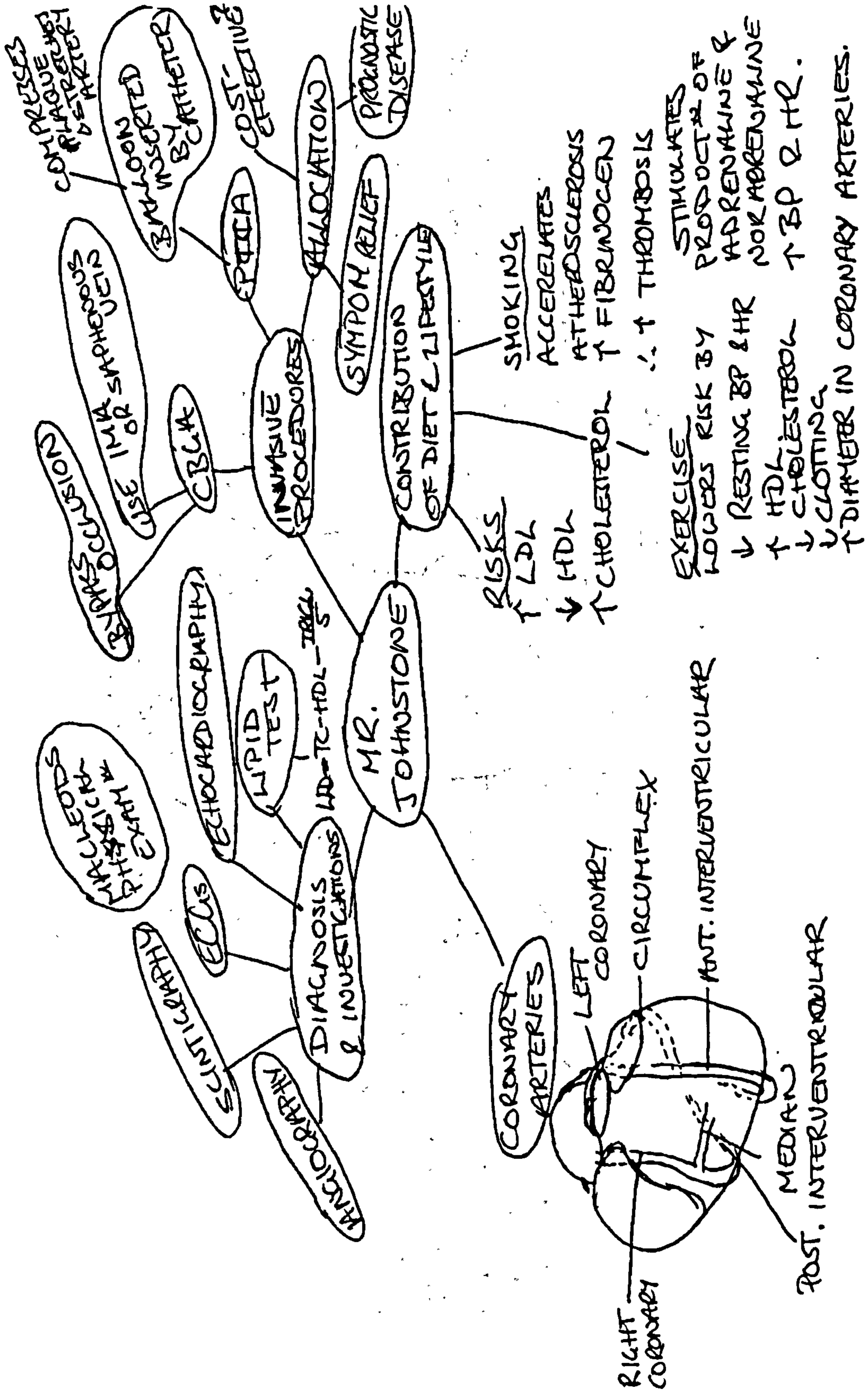


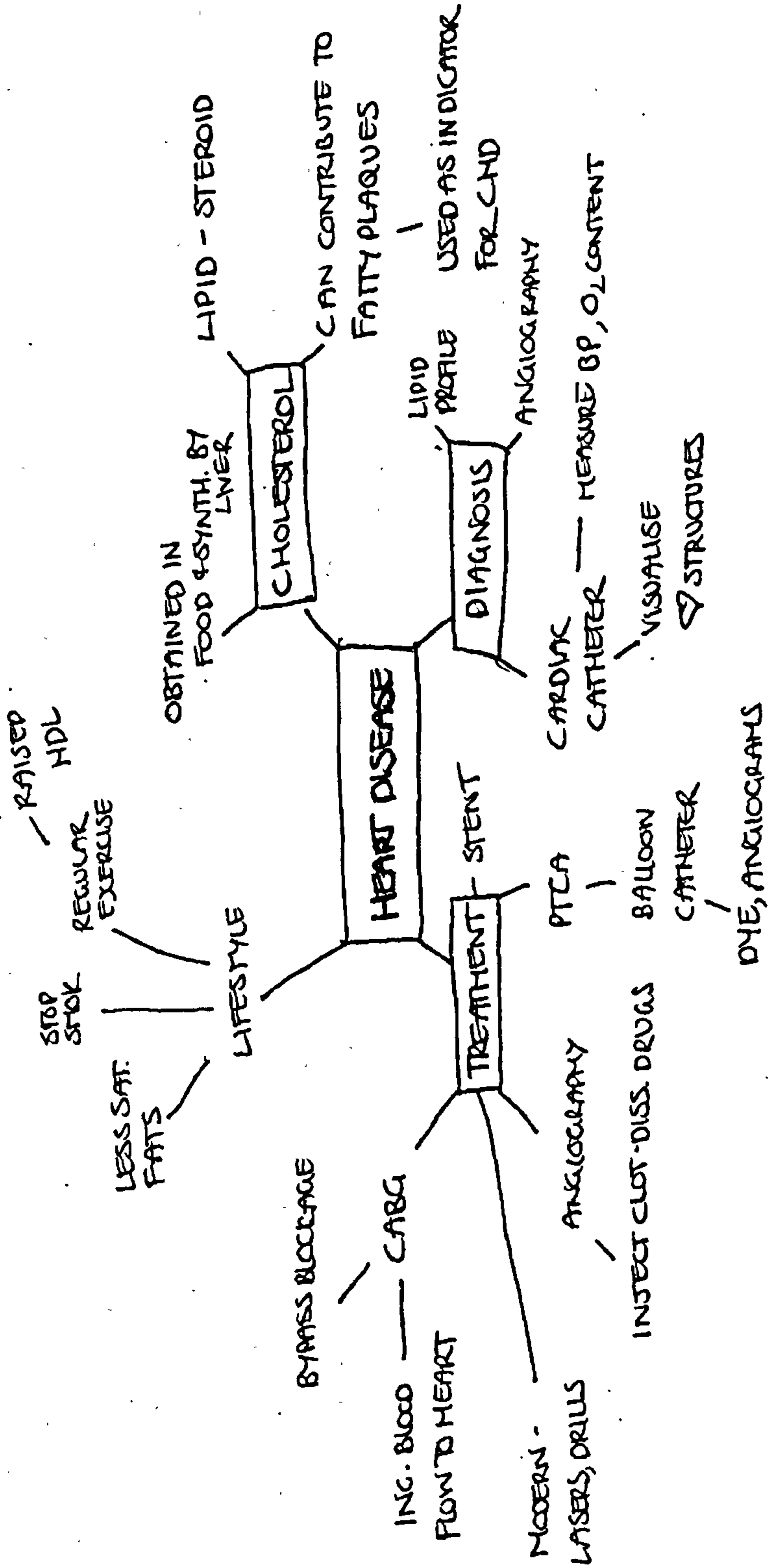












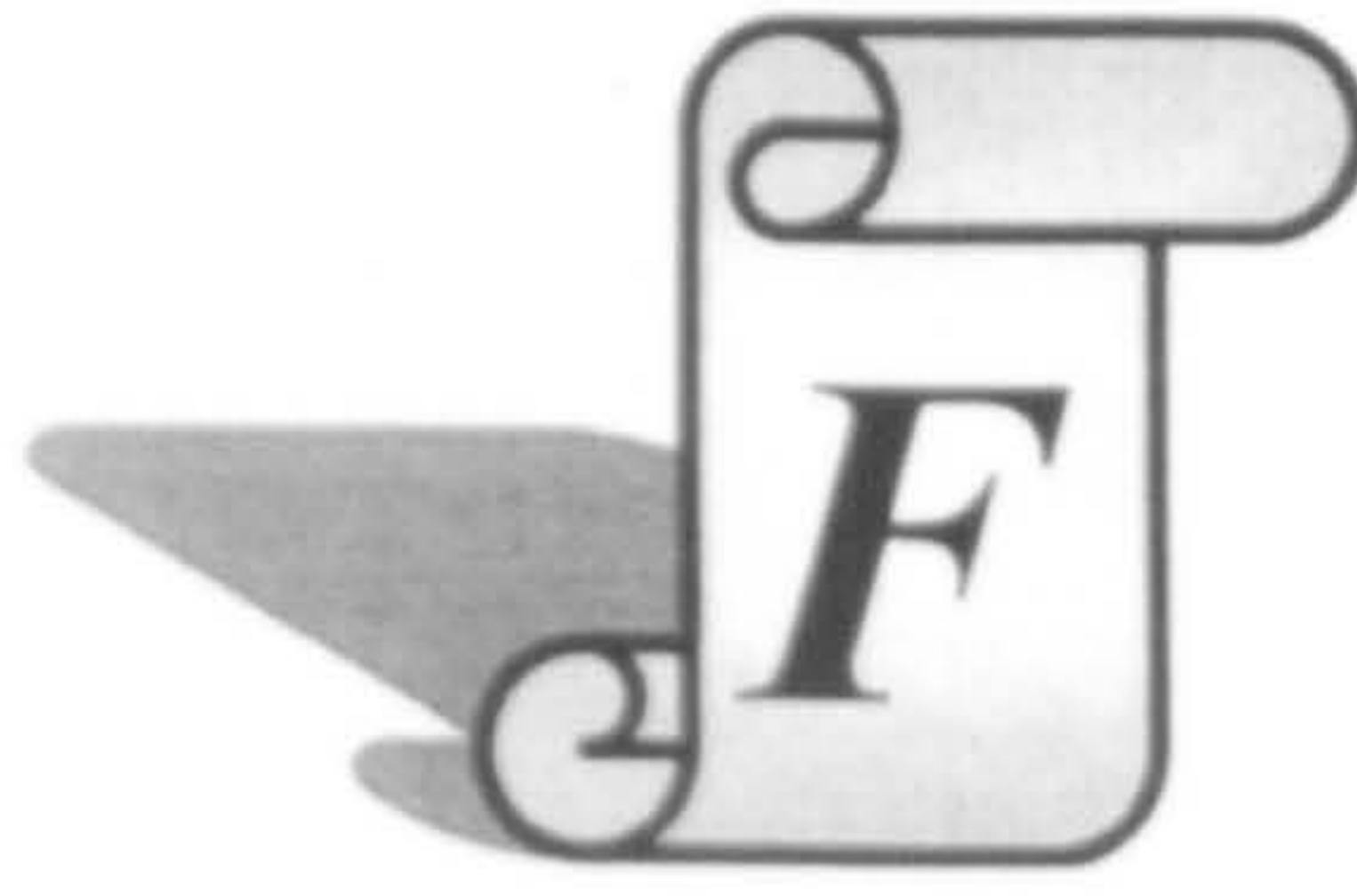
Student 222 - Scenario 9











*Appendix F*

*Concept Map attributes, quantitative and qualitative*

<i>Student #: 201.....</i>	<i>F1</i>
<i>Student #: 206.....</i>	<i>F1</i>
<i>Student #: 225.....</i>	<i>F2</i>
<i>Student #: 277.....</i>	<i>F2</i>
<i>Student #: 210.....</i>	<i>F3</i>
<i>Student #: 252.....</i>	<i>F3</i>
<i>Student #: 234.....</i>	<i>F4</i>
<i>Student #: 252.....</i>	<i>F4</i>
<i>Student #: 212.....</i>	<i>F5</i>
<i>Student #: 234.....</i>	<i>F5</i>

Student #: 201

PBL Group: 23

Scenario: 1

Main Issues: Mental Illness, Incidence/Prevalence

# of Questions: 6

# of Nodes: 24

# of Layers: 5          Layer 1: 4          Layer 2: 4

enough info to explain scenario: yes

Comments: Illness, Iceberg, Incidence and Prevalence in one node, 3 branches – 2 specific to general, 1 general to specific, lists and sentences on periphery

Student #: 206

PBL Group: 23

Scenario: 1

Main Issues: Mental Illness, Incidence/Prevalence

# of Questions: 6

# of Nodes: 29

# of Layers: 4          Layer 1: 4          Layer 2: 9

enough info to explain scenario: no

Comments: Illness, Iceberg, Incidence and Prevalence in one node, drawings, simplistic but not terrible



Student #: 225

PBL Group: 25

Scenario: 1

Main Issues: Mental Health, Incidence/Prevalence, Stigma

# of Questions: 4

# of Nodes: 48

# of Layers: 4          Layer 1: 3          Layer 2: 10

enough info to explain scenario: yes

Comments: Mental Health, Stigma, layered, drawings, layout ok, content fair, Incidence/Prevalence 1 node, 2 part form

Student #: 277

PBL Group: 31

Scenario: 1

Main Issues: Mental Health, Iceberg, Anxiety

# of Questions: 6

# of Nodes: 53

# of Layers: 5          Layer 1: 2          Layer 2: 12

enough info to explain scenario: no

Comments: Triggers, Anxiety, drawings, poor layout, map in two clusters, confusing mix of detail

Student #: 210

PBL Group: 24

Scenario: 2

Main Issues: Tiredness, Exhaustion

# of Questions: 7

# of Nodes: 47

# of Layers: 4          Layer 1: 4          Layer 2: 18

enough info to explain scenario: no

Comments: Tiredness, layout poor, content ok

Student #: 252

PBL Group: 28

Scenario: 2

Main Issues: Tiredness, Nerve tonics

# of Questions: 6

# of Nodes: 89

# of Layers: 4          Layer 1: 4          Layer 2: 23

enough info to explain scenario: yes

Comments: Fatigue, Tiredness, highly branched, very detailed, 2 part form



Student #: 234

PBL Group: 26

Scenario: 3

Main Issues: Eating disorders, Vegantarian, Teenage mothers

# of Questions: 7

# of Nodes: 45

# of Layers: 4      Layer 1: 3      Layer 2: 12

enough info to explain scenario: no

Comments: Vegan, planar, sentences, lists

Student #: 252

PBL Group: 28

Scenario: 3

Main Issues: Confidentiality, Frustration, Stress

# of Questions: 5

# of Nodes: 49

# of Layers: 4      Layer 1: 5      Layer 2: 17

enough info to explain scenario: no

Comments: Confidentiality, planar, nice branching, simplistic but logical

Student #: 212

PBL Group: 24

Scenario: 5

Main Issues: Smoking, Social Classes, Alcohol, GPASS

# of Questions: 6

# of Nodes: 67

# of Layers: 5          Layer 1: 3          Layer 2: 15

enough info to explain scenario: no

Comments: All main issues – level 1 nodes, lists, sentences, arrows, planar

Student #: 234

PBL Group: 26

Scenario: 6

Main Issues: Cough, Age, Antibiotic

# of Questions: 5

# of Nodes: 83

# of Layers: 5          Layer 1: 2          Layer 2: 5

enough info to explain scenario: no

Comments arrows, cross links, well branched, nice effort





## *Appendix G*

### *Concept Maps, nodes and layers*

<i>STUDENT # 201</i> .....	<i>G1</i>
<i>STUDENT # 202</i> .....	<i>G1</i>
<i>STUDENT # 209</i> .....	<i>G2</i>
<i>STUDENT # 210</i> .....	<i>G2</i>
<i>STUDENT # 213</i> .....	<i>G3</i>
<i>STUDENT # 226</i> .....	<i>G3</i>
<i>STUDENT # 234</i> .....	<i>G4</i>
<i>STUDENT # 246</i> .....	<i>G4</i>
<i>STUDENT # 274</i> .....	<i>G5</i>
<i>STUDENT # 278</i> .....	<i>G5</i>
<i>STUDENT # 279</i> .....	<i>G6</i>
<i>STUDENT # 280</i> .....	<i>G6</i>

## STUDENT 201

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	24	5	4	4	X
2	6	22	4	4	6	
3	6	39	4	6	8	
4	8	50	4	6	16	
5	9	41	6	3	11	
6	5	45	6	2	6	
7	5	53	5	3	8	
8	7	51	4	3	6	
9	6	48	5	4	9	
10	5	14	2	6	8	

## STUDENT 202

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	53	6	3	6	
2	6	51	4	3	6	
3	6	48	3	4	9	
4	8	83	6	5	14	
5	9	60	3	12	37	X
6	5	81	2	15	66	X
7	5	77	4	8	25	
8	7	49	4	3	14	
9	6	46	5	5	19	
10	5	22	3	3	10	



## STUDENT 209

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	15	3	3	7	
2	6	32	3	10	19	
3	6	48	4	5	24	X
4	8	31	4	5	16	
5	9	46	4	4	15	
6	5	-	-	-	-	
7	5	53	5	4	10	X
8	7	57	4	5	14	
9	6	56	4	5	15	
10	5	38	4	3	12	

## STUDENT 210

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	45	5	4	13	
2	7	47	4	4	18	
3	11	44	3	5	19	
4	5	46	4	3	14	
5	6	47	4	4	12	X
6	3	46	5	3	15	X
7	4	-	-	-	-	
8	2	44	4	3	9	
9	6	45	5	4	12	
10	5	32	4	5	12	

## STUDENT 213

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	68	5	5	8	X
2	7	68	9	5	7	X
3	11	67	5	6	12	X
4	5	71	6	8	15	X
5	6	72	5	4	16	X
6	3	69	6	5	9	X
7	4	68	7	5	14	
8	2	70	12	4	12	X
9	5	-	-	-	-	
10	5	68	6	2	7	

## STUDENT 226

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	4	20	3	4	8	
2	5	37	3	4	20	
3	4	48	3	4	15	
4	5	46	4	4	13	
5	5	42	4	3	5	
6	3	32	3	4	20	
7	6	46	3	7	23	
8	3	35	3	5	21	
9	5	32	3	4	14	
10	3	35	4	3	23	X



## STUDENT 234

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	48	3	4	8	
2	7	45	5	2	4	
3	7	45	4	3	12	
4	5	46	4	4	11	
5	8	45	3	3	13	X
6	6	43	3	5	14	X
7	5	44	3	7	28	
8	6	46	4	3	13	
9	7	44	6	3	12	
10	7	-	-	-	-	

## STUDENT 246

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	4	28	3	5	16	
2	6	65	5	5	13	
3	5	49	4	5	17	X
4	5	66	5	4	18	
5	7	67	3	4	22	X
6	5	59	4	6	22	
7	6	52	5	5	18	
8	4	57	5	4	12	
9	8	52	4	5	14	
10	6	41	3	4	15	

## STUDENT 274

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	134	4	3	11	X
2	6	110	4	3	15	X
3	6	114	4	3	11	X
4	5	106	4	8	25	
5	4	114	4	4	17	X
6	4	106	4	5	15	X
7	4	108	5	8	14	X
8	5	102	5	4	23	X
9	5	106	5	5	17	
10	4	72	4	4	21	

## STUDENT 278

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	42	5	3	16	
2	6	60	4	3	14	X
3	6	81	4	4	12	X
4	5	79	4	4	15	X
5	4	74	4	3	16	
6	4	57	4	4	16	
7	4	41	4	2	10	
8	5	65	5	3	14	
9	5	62	5	4	15	
10	4	55	4	3	12	



## STUDENT 279

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	60	4	4	10	
2	6	59	4	4	14	
3	6	58	4	3	6	
4	5	58	4	3	11	
5	4	59	4	3	11	X
6	4	61	4	5	26	
7	4	60	5	4	19	
8	5	59	5	4	10	X
9	5	58	5	5	12	
10	4	44	4	4	16	

## STUDENT 280

Scenario	Questions	Nodes	Layers	Layer 1	Layer 2	Adequacy
1	6	25	2	6	19	
2	6	26	2	6	20	
3	6	47	4	5	16	
4	5	40	4	5	21	
5	4	59	3	5	10	
6	4	53	4	5	9	
7	4	41	2	7	34	
8	5	48	4	5	15	
9	5	51	4	5	12	
10	4	47	4	3	15	



*Appendix H*

*Final exam scores and statistics*

*FINAL EXAM SCORES..... H1*

*STATISTICS..... H4*

100	100
101	100
102	100
103	100
104	100
105	100
106	100
107	100
108	100
109	100
110	100
111	100
112	100
113	100
114	100
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187	100
188	100
189	100
190	100
191	100
192	100
193	100
194	100
195	100
196	100
197	100
198	100
199	100
200	100



<b>Final Exam Scores</b>	&&&	68.6	&CC	70.9
<b>Control Group &amp;&amp;&amp;</b>	&CC	76.5	&&&	70.5
<b>Group C &amp;C&amp;</b>	&CC	70.8	&C&	73.4
<b>Test Group &amp;CC</b>	&&&	77.2	&&&	64.5
&&&	&&&	63.8	&&&	63.3
&&&	&&&	61.7	&&&	65.2
&C&	&CC	62.9	&&&	65.3
&C&	&&&	64.5	&&&	71.7
&CC	&&&	68	&&&	67.3
&&&	&&&	70.1	&&&	69.7
&&&	&&&	58.1	&&&	63.9
&&&	&&&	59.6	&CC	61
&&&	&&&	66.4	&CC	64.3
&&&	&CC	76.3	&&&	56.3
&&&	&&&	68.7	&&&	59.1
&&&	&&&	41.5	&CC	64
&&&	&&&	60	&C&	63.2
&&&	&&&	64.8	&CC	63
&&&	&CC	70	&&&	63.5
&&&	&CC	71.3	&&&	61.5
&&&	&&&	76	&&&	69.4
&&&	&CC	79.8	&&&	65
&&&	&&&	66.4	&&&	55.7
&&&	&&&	63.2	&C&	50
&&&	&CC	67.4	&&&	67.8
&CC	&&&	67.7	&&&	74.1
&&&	&CC	62.2	&&&	69.3
&CC	&&&	66.1	&&&	70.3
&&&	&&&	68.1	&&&	62
&CC	&&&	70.7	&CC	63.3

&&&	719	&C&	61	&&&	67.3
&&&	663	&C&	693	&&&	69.1
&&&	718	&&&	69.6	&CC	72.3
&&&	669	&&&	63.1	&&&	71.5
&CC	663	&C&	53.7	&CC	66.8
&&&	724	&&&	71.6	&&&	68.2
&C&	599	&CC	71.7	&&&	69.8
&C&	619	&C&	67.2	&&&	72.2
&C&	629	&CC	60.7	&&&	62.6
&&&	672	&&&	74.5	&&&	64.3
&CC	705	&CC	68.8	&&&	67.6
&&&	617	&&&	76.4	&&&	69.7
&&&	693	&&&	66.1	&&&	67.9
&CC	651	&CC	69.1	&&&	68.1
&&&	621	&&&	69.6	&&&	64.7
&&&	654	&C&	64.6	&&&	70
&&&	681	&CC	67.6	&CC	63.2
&&&	685	&&&	66.2	&&&	69
&&&	722	&&&	74.3	&&&	63.2
&CC	682	&CC	75.8	&CC	68.3
&&&	624	&CC	61.6	&&&	65.7
&CC	668	&&&	69.4	&&&	59.9
&&&	659	&CC	70.3	&&&	62.8
&&&	668	&&&	62.9	&CC	78.2
&CC	69	&&&	68.9	&&&	67.9
&&&	711	&&&	62.9	&&&	65.1
&&&	723	&&&	63.9	&&&	61.6
&CC	694	&&&	67.4	&CC	66.8
&&&	58	&&&	61	&&&	57.9
&&&	569	&CC	76.7	&&&	66.9



&CC	67 6	&&&	68.7	&&&	75.7
&&&	67 1	&CC	71.6	&&&	67.7
&CC	67 7	&&&	61.2	&&&	64.5
&&&	58	&&&	63 9	&&&	66.8
&&&	68 8	&&&	64.1	&C&	68.3
&&&	70 4	&&&	73 9	&CC	52.6
&&&	63 4	&CC	74	&&&	61.6
&&&	66	&&&	75	&&&	71.1
&&&	71 2	&&&	63 7	&&&	74.7
&C&	61 9	&&&	76 3	&CC	74.9
&&&	68	&&&	65.3	&CC	73.2
&&&	62 6	&&&	67 6	&CC	65
&CC	67 3	&&&	71 8	&&&	68.8
&CC	61	&&&	77	&&&	75.2
&CC	64	&CC	63.9	&&&	60.2
&&&	68 9	&CC	66 1	&CC	69.9
&C&	60 2	&&&	67	&CC	69.4
&CC	63 6	&&&	69 2	&&&	61.4
&CC	69 6	&&&	70 3	&&&	65.4
&CC	64 7	&&&	67 6	&C&	61.3
&C&	64 9	&&&	71 6	&&&	73.5
&&&	61 6	&&&	65 2	&&&	59 6
&C&	67 7	&&&	74 1		
&CC	76 5	&&&	63 1		

Group Statistics

Experimental Group	N	Mean	Standard Deviation	Standard Error Mean
Control	185	66.27	5.47	.40
Test	60	68.23	5.22	.67

t-test for Equality of Means

	t	df	Sig 2-tailed	Mean Difference	Std. Error Difference	95% C. I. of Difference	
						Lower	Upper
Equal variances assumed	-2.436	243	.016	-1.957	.803	-3.540	-.374
Equal variances not assumed	-2.492	104.061	.014	-1.957	.785	-3.515	-.399

