COGNITION AND TEACHING IN SUBJECT SPECIFIC AREAS

An investigation into the Cognitive Skills required by pupils to master Concept Formation in the field of Homeostasis, an aspect of Human Physiology.

BY:

FOZEA FRYDDIE

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DECLARATION

I declare that this "Investigation into the Cognitive Skills required by pupils to master Concept Formation in the field of Homeostasis, an aspect of Human Physiology" is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Signed :_____

Date:_____

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ABSTRACT

Pupils experience various problems when trying to solve problems in Biology, particularly on Higher Grade. This problem was profound in the area of Homeostasis, an aspect of Human Physiology. During this investigation a number of pupils, the PIONEER GROUP, were screened for cognitive deficiencies. Major common deficiencies were identified as IMPULSIVITY, THE USE TWO OR MORE SOURCES OF INFORMATION SIMULTANEOUSLY, SPATIAL AND TEMPORAL ORIENTATION.

A second phase, the essence of this investigation, sought ways in which to teach pupils the cognitive skills to facilitate their concept formation in the area of Homeostasis. Since the subjects displaying these cognitive deficiencies were already in their final year of High School a method was sought which would benefit them in the short term. Simultaneously a way had to be found to teach these skills so that it could be of use to pupils on a long term basis.

This study revealed that for short term benefit the cognitive skills have to be subtly introduced and integrated with the subject content. Teaching cognitive skills in concentrated form over such a short period had a detrimental effect on the group subjected to this treatment.

However, the PIONEER GROUP, had been taught these skills in a very short period in concentrated form. Feedback from them reveals that they were not able to apply the skills in their Senior Certificate Examination but all of them are now adept at using these skills to their benefit. This leads to the conclusion that if these skills are to be taught separately it should be started as early as possible in the school career. In the last year of High School it is more of a burden to the pupil than a benefit. In such a case it should be done integrated with subject content.

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A P P E N D I C E S

C H A P T E R 1

I N T R O D U C T I O N

1.1 SKETCHING THE BACKGROUND TO THE INVESTIGATION

This investigation was sparked of primarily as part of a broader inquiry into the needs of pupils to master Science at High School level. Long term exposure to Senior Certificate candidates from various high schools and experience with my own Senior Certificate pupils confirmed the suspicion that these pupils need help desperately. My experience as sub=examiner of Higher Grade Biology at Senior Certificate level enabled the recognition of a weakness in the integrative activities required particularly on the Higher Grade. From the answers provided by pupils it became evident that most of them were groping for substance for their answers. An ignorance in the sphere of understanding and integrating concepts became apparent. Pupils were monitored over a period of two years in an attempt to find the cause(s) of the problem(s) which they were experiencing.

The aim of the investigation is to identify these causes in order to avoid recurrence of the problems. Great emphasis is placed on elimination of the causes rather than treating the effects. This led to the investigation programme which is discussed in Chapter Four. Two years prior to the actual program

work has been done in this area on a remedial rather than preventative basis. At this stage, however,much of the work done in this field was not known and adequate steps at prevention could not be taken. It is only upon embarking on this course of study that it was possible to work out a programme which would assist pupils to cope with their problem-solving activities.

Having identified the problem and correctly 'labelling' it, it was possible to devise a program which would address the deficiencies in pupil behaviour during problem solving. It was not an easy task as a 'correct' method of instruction to enable the pupils to acquire the skills which they lacked was not known to me. It is for this reason that I had used three groups to work with, TWO EXPERIMENTAL and one CONTROL GROUP. From the results obtained certain suggestions are made with regard to the prevention of these problems which could result in the elimination of the need for a time consuming remedial programme.

This investigation is not aimed at promoting any school of thought or perspective on education. It is merely an attempt at equipping the pupils of Biology, particularly on the Higher Grade, to cope with problems where much integration of material is required. It must, however, be stressed that the Standard Grade Biology pupils also benefit greatly from this programme, allowing them greater insight into their limited subject matter. These pupils are often told only 'half the story' and it is surely more difficult to grasp something if only 'half' of the information is known.

Although this aspect of the investigation can be regarded as complete a concurrent programme is still under way. This would hopefully lead to this programme being taken further than just the Biology Classroom.

1.2 THE RESEARCH TOPIC

The problem was identified as an aspect of Human Physiology as prescribed by the Department of Education and Culture (DEC) (Bulletin SS 9/86). Since "HOMEOSTASIS" encompasses all aspects of Human Physiology in the set syllabus for Senior Biology pupils this topic was the automatic choice. The concepts required are of primary importance across a few chapters giving the investigator a good chance of forging links between the chapters thereby enhancing the integratory skills of the pupils. As the thesis title suggests the programme is aimed at investigating the Cognitive Skills required to master the formation of concepts related to Homeostasis.

This would, with the aid of selected Heuristics, hopefully lead to successful integration of the concepts and a subsequent holistic view of Homeostasis. As described earlier, pupils country-wide are experiencing problems with this section of Biology. Of secondary importance in this programme is the search for a method of teaching which would enable pupils to cope not only with Homeostasis, but also to transfer the skills acquired to other areas of their curriculum to improve their performance in those areas as well. A detailed description of the investigation follows in Chapter Four.

1.3 PERSPECTIVES OF THE PROBLEM

In an encounter with College students some years ago some 'gaps' in their knowledge of Biology became apparent. The factual content and level of understanding of many biological concepts were suspect. This aroused great concern as most of these students were in-service teachers teaching General Science and Biology. The freshmen who attended the Biology classes claiming to have taken Biology throughout their high school careers were guilty of the same deficiencies. This was a suggestion that somewhere along the way some teachers are perpetuating misconceptions and their pupils who later may become teachers continue the vicious cycle.

What caused greater concern was the following comment made by one of the teachers: "I have been teaching 'it' like this all the years, why should I change now?". This cruel reality as a first encounter with the actual education system was a shock. Further experience as teacher in a high school exposed a similar situation. Many pupils were groping for answers, many in such clouded and mystified environments that their attempts were seldom fruitful. Basic definitions of concepts were vague. Those pupils who could recite the text book definitions of the concepts were unable to use it meaningfully in a paragraph. The greatest problem was in the field of human Anatomy and Physiology. From answers given in tests and general conversation with pupils it became apparent that their knowledge and level of understanding centered around what they could physically see and what they knew from previous experience.

In order to get a good idea of the misconceptions or alternate conceptions which the pupils hold they were confronted with charts and/or models. Discussing the exhibits in a very informal way amongst themselves their erroneous ideas would surface and be noted. The level of understanding of the specific topic would also be noted. These misconceptions and over- generalizations of the pupils caused grave concern. During the ensuing lesson on the topic a special effort was made to address these aspects and set the record straight.

The inability of most Senior Certificate pupils to integrate information from various sections of a chapter was apparent from the answers supplied in their Senior Certificate examinations. They fared even worse when required to integrate aspects from different chapters as is often required for the higher grade essays. This raised many questions about not only how I teach Biology but also how Biology is taught in general in schools. This in turn forced a look at the situation at schools and the education system under which they operate.

1.4 MOTIVATION FOR THE RESEARCH

The problem situation that existed as described above was enough motivation for this research. In addition to the problems the pupils were confronted with there were other factors such as those mentioned in the last paragraph above.

Examining the situation at schools brought forth the following. Local school administration and Internal School Policy, if it existed at any school in the DEC, left much to be desired. At many schools the good pupils receive all the attention and improve while the 'bad' ones are left to their own devices. This group has all sorts of stigmas attached to them. Throughout their school career these poor performers are branded as 'stupid' or 'non-academic' and very little is done to improve their conditions. Guidance, vocational and other, at many schools is not a priority and many in need of guidance and counselling are left to their own devices. They often turn out to be the early school leavers who take to the streets.

Many teachers hold the opinion that the pupil has to conform to their methods, fail, or get out of their classes. The presence of this 'low-achieving element' increases the urge to try and help the pupils by providing them with the tools to help themselves. Too many situations exist where pupils at primary and secondary level are scorned by teachers instead of being helped. Very often the teachers involved are highly qualified academics who appear to be more fit for instruction in tertiary instutions. At this point the following phrase comes to mind:

Those who can (educate) do
Those who can't, teach
Those who can't (teach)
Become university lecturers

This state of education exists at most schools and is worsened by the prevailing system of government. Not only did the policy of

racial segregation undermine the opportunities for adequate exposure of both teacher and pupil, but it also places constraints on the local educational practice. The latter arose due to the circumstances listed below:

* the politico-educational climate which was created over the years in the townships
* the attitude school administrators have by the 'powers vested in them'
* the attitude certain 'Community Leaders' have developed due to their socio-economic status in their respective communities.

This situation is currently still prevailing but will hopefully soon be buried.

Reports on the final examinations compiled by examiners indicated a problem in the mastery of homeostasis. The validity of these reports was not known until first-hand experience was gained during the marking of final examination papers. Since Human Physiology became more profound in the 1988 Biology Syllabus the problem in this area became more apparent. It was clear from answers given by many pupils that they had difficulty in communicating their thoughts and integrating information across the artificial barriers which the syllabus has conveniently built in.

This need was felt by many teachers of Biology and an attempt was made at setting standard examinations in Biology and General Science for a number of schools in the area. This venture was not successful as most teachers have sport commitments and/or 'much else' to do after school. After all why should teachers worry

about the quality of examination papers?

Teachers at most schools make sure that their pupils know the work that will be examined. Some teachers at some schools make sure that their pupils know **only** the work that will be examined. They do little else to stimulate the minds of their pupils. Many other malpractices which have negative effects on the development of the pupils are ongoing at schools. The teaching situation at many schools is neither inviting nor stimulating for teacher or pupil.

The following questions come to mind at this stage:

* When are principals going to take the responsibility which is inherent in their pay-cheques?
* Do our schools have school policies?
  IF SO
* Do parents and pupils know about the school policy?
* Do they **know** the school policy?
* Do they participate in the formulation of the policy?
* Are they aware of the implications of contravening this policy?
* Are teachers aware of the school policy?
* Do they participate in the formulation of the policy?
* Is there some form of DEMOCRACY anywhere in the schools system?
* Do we (schools, community, and other societal structures) not criticise the state government for the absence of Democracy?
* What is our contribution to bringing about Democracy?
* Do educators and administrators exercise the Democracy they shout for?

The first question will be addressed in detail in Chapter Five. If this aspect could be straightened out the rest would fall into place. **It is not important to chalk up results**. What is important is that the pupil be aided as much as possible in a more direct, yet democratic, way to become the 'responsible adult' society expects him/her to be. On the basis of the outcome of this investigation some recommendations would be made in this regard. What would help for the time being , is to equip the learner with some skills instead of pumping the learner full of factual data.

These skills are aimed at enabling the learner to remember, apply and manipulate the information. Basic facts can always be looked up in an Encyclopaedia or text book if required at a much later stage, but the skills they learn they should be able to use in many spheres of life.

Most pupils 'empty out' or 'regurgitate' the information pumped in and have or want to have nothing more to do with it after the examination. It is so important to be able to apply ones knowledge that the instruction of the appropriate cognitive skills is advocated as early in formal schooling as possible.

1.5 SOME GENERAL INFORMATION

While this investigation was underway the opportunity to visit an American University became available; an ideal opportunity to further the investigation with a different group of pupils. Whilst in America this part of the investigation was facilitated by members of Harvard University with whom I was working. Braintree High School became the focus of this investigation. Interviews were conducted with some pupils of the Advance Placement Biology Group and also with some A.P. Chemistry pupils. This school enjoys the academic status as the school where the greater part of the investigation was conducted. I regarded this aspect as important as it is not wise to compare pupils of different academic levels. The processes and findings are discussed in Chapter Four.

1.6 CONCLUSION

In the ensuing five chapters I shall try to elaborate on issues mentioned in this introduction. Chapter Two will serve to clarify my literature search. In Chapter Three I will discuss the Theories which have a significant impact on my motivation for the research and the actual investigation. I hope to make my research project and findings clear in a rather lengthy Chapter Four and also address some of the positive aspects of the project as well as the difficulties which my pupils and I had experienced during the course of the project.

In Chapter Five inferences will be drawn and general directions given to highlight the significance of hte research. Chapter Six provides concluding statements, something which is aimed at stimulating further research in this field. The speculations and suggestions are as explicit and transparent as possible. Guidelines for possible future operations are provided. This is aimed at stimulating the interested reader and supplying him/her with some starting point in Cognitive Instruction.

A detailed breakdown of the various chapters provided in the Index provides more information on the content of each chapter.

C H A P T E R 2

L I T E R A T U R E R E V I E W

2.1 A GENERAL NOTE

It is important in an investigation to keep a clear and open mind to do justice to the outcome(s) of the investigation. Although many aspects of Educational Theory and Practice was already part of the everyday teaching event a firm theoretical background of the theories used for the major part of the investigation was lacking. Piaget's 'Stages of Development' was a starting point for the identification of the existing problem. The study of Feuerstein's work in the field of Cognitive Operations and the work done by Whimbey and Lochhead in the field of Problem Solving gave direction to this investigation.

The status quo with regard to research in the field of this investigation was not very well known until the investigation was completed. A primary reason was to avoid an 'expected outcome'. The Literature survey started toward the conclusion of the investigation in local libraries. Due to time constraints and availability of materials I was none the wiser upon completion of

the investigation. At this time, bound for USA, the local search was abandoned, to be resumed at the many Harvard Libraries with its rich and readily available, particularly primary, sources. Quick reference was given to Libraries such as that of Boston College or Radcliffe College if not kept in the Harvard Libraries.

2.2 EDUCATIONAL BASIS FOR THE RESEARCH

2.2.1 THE NEED FOR SUCH AN INVESTIGATION

A quote from a college student which marks the opening of the preface to the book 'Cognitive Process Instruction' is ideal to open this paragraph. He says: "They should have a course to teach you **how** to learn...All they have is courses on **what** to learn". This finds support with the utterance of one of the subjects of the Experimental Group 1 who said: "All the time they teach you **what** to think....Now that you're almost out of school they want to teach you **how** to think". Jack Lochhead, co-author of "Problem Solving and Comprehension", has used similar phrases in the sessions in which he presented Heuristics to our group. The introduction of Part II in 'Developing Minds' (Costa, 1985:11) quotes Lochhead :"We should be teaching students how to think; instead, we are teaching them what to think." This phrase of his is also part of his introduction to Cognitive Process Instruction (Lochhead, 1979:1).

This represents an urgent call by students realizing what they are missing to enhance their cognitive performance. It also illuminates the realization by experts in the field of cognitive instruction that the pattern of classroom teaching needs a change from **what** to **how** i.e. from prescriptive to descriptive.

Ruggeiro(1988:2) poses the following question and proceeds to answer it as well: "Is the thinking skills 'crisis' a media invention? The media have not created a problem where there was none;they have merely reported on the studies that have documented the problem."

Novak and Tyler (1977:17) cites the task of education as transmitting to the children the concepts and practices of their culture which they would need as adults. Since concepts and practices change over time it is important to select carefully those that are of more lasting value, but also must assist children in acquiring the capacity to generate and use new ones. They continue (p.18) stating that if we cannot get our concepts clarified and organized, our thinking remains muddled up and we are successful neither in solving problems nor in generating new concepts that would help us solve them.

Otto (Guthrie,1979:195) asks the question: "Why skills?" and answers it by saying that we need skills to sharpen the focus of our teaching. But we must choose them sensibly and we must keep

them in perspective He continues as follows:

> "Once we concern ourselves with sensibly chosen skills...I think there will be less tendency to view them or to teach them in isolation. I see skills and the teaching of skills as the substance and the means for sharpening the process of developing reading comprehension. Skills must be identified, taught, and applied in context. In perspective skills can be the vehicle for moving children to independence in their reading comprehension."

According to Arons (Lochhead,1979:209) a large proportion of college students tend to use predominantly concrete as opposed to formal patterns of reasoning. Arons then sees this as "a profound discrepancy between most secondary school and college level course content as well as the actual reasoning patterns of students."

Ruggeiro (1988:2) has the following to say about this issue:

> "..few students are able to offer more than just superficial defenses for their views, elaborate on ideas, or extend their ideas into thoughtful discussion. Even more alarming...the percentage of students achieving higher order skills actually declined in the 1970's"

Gunstone and Watts (Driver,1985:102) have found in their study on Force and Motion that the beliefs children bring into the learning of mechanics are firmly held and is difficult to change. This difficulty being well illustrated by reports of successful physics students retaining common pre-instruction conceptions of the world. Clough and Driver (1986:473) point out that from an educational point of view it is necessary to take account of these ideas and beliefs so that these could be successfully modified by

instruction. The authors further note (p490) a more gloomy statement that there is evidence that some of these alternative conceptions are resistant to instruction (cf. Gunstone and Watts above) even when the teaching has been deliberately structured to incorporate or confront children's ideas.

The same, I believe, would hold for many other fields of study, particularly Biology in which I am involved. From experience in this field it has become evident that when pupils have a fixed set of ideas, however wrong these may be, it is extremely difficult, and in some cases impossible, to clear out these 'misconceptions' to make way for the correct information. Particularly in the case of the slower and the rote learner, where reasoning is minimal, the 'diseased condition' is almost untreatable.

Arons (Lochhead,1979:214) notes that much of the materials and instruction with which the students are confronted assumes that the students have the reasoning capacities required or would develop these capacities automatically with maturation and study of the subject matter. He pursues this assumption as follows:

> "It is becoming embarrassingly clear that such automatic development actually occurs only in a relatively small portion of our students - perhaps the upper 25 per cent, those whom we characterize as among the 'brightest'. The remainder, who might well develop such intellectual capacity at a slower pace, are not afforded the opportunity to do so. They need the time to reason slowly, to make mistakes and retrace their steps without being crushed or punished; to revise their thinking and test it themselves for internal consistency. Under

> pressure of the volume and pace of material with which they are deluged many students seek refuge in blind memorization and completely lose sight of the intellectual processes through which they could bring order into the chaos that seems to surround them. As a matter of fact they never develop any sense of their own intellect or of the deep satisfying feeling that emerges when one recognizes that he understands something."

Robbie Case (Kirby & Biggs,1980:16) asserts that the nature of the development which occurs during the stage of formal operations is probably less well understood than that which occurs during any other stage. Since more complex routines take account of more information, children need more than simple experience in order to acquire and use them (Ibid, 34). I have become aware that the pupils were not performing at the level I expected of them and because of this discrepancy I had undertaken this study to get an idea of where to start tackling the problem. I view the introduction of Heuristics to facilitate the cognitive operations as an essential step toward uplifting the poor level of cognitive development which characterize not only our school children but also the teachers. In order to facilitate understanding by pupils it is imperative that the teacher understands the underlying processes occuring in the cognitive structure of the pupil. Most teachers teach 'broad spectrum' to cover the whole class with one explanation instead of explaining in different ways, adapting the presentation of the information to suit the level of the pupil. A lack of deeper knowledge of information and flexibility in didactical methods often lead to the poor presentation prevalent among many teachers. Teaching the teachers how to teach would remove the enormous barriers the pupils see in their efforts to

understand.

Alan Schoenfeld (Lochhead,1979:319) sums up the situation intensely concise:

> In brief, we must be as serious about instruction in heuristics as we are about any other mathematical techniques; with any less than that degree of classroom attention, we cannot realistically expect students to learn to use heuristic strategies"

With the above as evidence it is clear that WE NEED TO HELP THE CHILDREN FIND THEIR WAY AROUND THINKING...

2.2.2 CURRENT PROGRAMMES AND EVENTS

Part of the instruction programme, deliberate and integrated, was to teach pupils how to read. Pupils were taught to extract the essence(s) by using various techniques. It is for this reason that programmes related to reading instruction was sought for as well. The following are examples of such programmes.

Carroll (Guthrie,1979:11) explains the operation of the Cognitive Ability Scale of the Written-Oral-Comprehension (W.O.C) Scale which is intended to improve the language comprehension skills of

learners. He sees the teaching of vocabulary for the concepts that the individual is able to handle as slow and difficult. Instead, he proposes the teaching of strategies for understanding sentences and paragraphs in both spoken and written form. Otto (Ibid:198) describes the Wisconsin Design for Reading Skill Development (WDRSD) which is also intended to improve reading comprehension skills.

Stauffer (Ibid:246) expands on the Directed Reading-Thinking Activities (DRTA's) and explains that recent studies have shown quite clearly that what the teacher does makes an enormous difference to what the learner is able to do. It is argued that the Reading-Thinking (R-T) process must begin in the mind of the reader through questions that s/he raises. The teacher must keep the inquiry going by changing the nature and amounts of the data to be processed and the nature of the questions being asked. Ruggeiro (1988:2) draws much information from the National Assessment of Educational Progress, a program designed for monitoring educational performance or non-performance in the United States. The concept of Guided Design, developed by Charles Wales and Robert Stager for the University of West Virginia Engineering Program, has been used successfully in Chemistry, Communications, Computer Science, Counselling, Journalism, etc. (Ruggeiro, 1988:10). This displays the use of teaching of thinking skills - not being subject specific. In this case the program was applied across a broad spectrum of content. D'Armour (Lochhead, 1979:188) recongizes

this program as based on the belief that teachers have much more to offer their charges than simple facts. He suggests that teachers can offer a model of how an intelligent human being makes scientific judgments. Guided Design is thus part system and part attitude, reshaping the traditional approach to higher education.

Feuerstein's Instrumental Enrichment is an Intervention Program for Cognitive Modifiability. He makes use of the Learning Potential Assessment Device (LPAD) in his program to improve the achievement of retarded performers. More details on this philosophy in Chapter Three. Purser and Renner has used the CAP (Cognitive Analysis Project) in their investigation to determine the results of the teaching procedures which they had applied in their teaching of Biology. This Project designed and tested procedures to measure the intellectual development of groups of students. They also used the GEFT (Group Embodied Figures Test) to determine the correlation of the intellectual development on the Piagetian-Inhelder scale (Purser & Renner, 1983:91).

The UWC's OUTREACH program designed to help pupils perform better in the Sciences and Math has been in operation for some years. The impact of this program on education has yet to be assessed. The Departments of Zoology, Botany and Physics are offering practical courses to improve the practical aspect of the matriculant's curriculum. This is currently done on a small scale, but very successful. With more resources and facility it will

hopefully become open to more pupils on a more regular basis.

In recent lectures and workshops I have attended since my return from the USA it is clear that the problem of Cognitive Instruction and the improvement of the teacher in his capacity as a means for pupil understanding are receiving much attention. A speaker at a workshop reported of a visit to the "Harare Generator" Conference where delegates from all over Africa congregated to discuss the state of education in their respective Countries. At this Conference, which was held after mid=1990, the "ZimSci-Project" (Zimbabwean Science Project) was also discussed with a delegate from Zimbabwe. The Project was traced back to 1984. At the same workshop mention was made of the newly established "Share-Net" organised by Wits University where teachers also have the opportunity to meet and share resources and ideas.

Since July this year (1991) have been running OPERATION CRANIUM COMMANDER at the school where I teach only in the classes which I teach. I hope to broaden the horizons of this programme to include not only other classes at our school but also other schools as well.

Hundreds more of these 'ready made' programs which teachers could study or use as a start could be dug up. However, it would be more useful to provide a scheme for developing an 'own' program to teach thinking skills.

2.3 DEVELOPING YOUR OWN THINKING SKILLS PROGRAMME

This whole paragraph is drawn from the 30-page booklet by Chuska (1986) and thus no 'on site' references are made. The Programme, K-12, is a programme for 'Teaching the Process of Thinking' as well as a section which allows a teacher to develop her/his own programme.

Very importantly Chuska recognizes the fact that little attention is paid in teacher education programmes to develop strategies for teaching thinking. What teachers need, he feels, is a common language across the subject areas and grade levels. A force of hindrance in teacher progress is the idea that the teaching of thinking is often thought of as an add-on rather than an integrated part of basic instruction.

A successful plan for developing an articulated thinking programme, K-12, must meet the following conditions:

1. A common vocabulary across subjects and grade levels must be sought
2. Common denominators in curriculum content must be identified to show commonalities across grade levels and subject areas
3. Ways of thinking must be delineated in order to give focus to instruction
4. The Plan must be manageable with respect to implementing, monitoring, and evaluating.
5. The Plan must make a distinction between process and product with respect to thinking.

6. An Inservice Programme for teachers must exist to acquaint them with the elements of the model and to provide them with background of other models of teaching thinking.

The teacher must remember that in order for thinking to occur there must be:

1. Something to think **about**
2. Something to think **with**
3. Some **ways** in which to think
4. Something to think **for**

All the above points are discussed in detail in the booklet as well as a chapter on implementing and evaluating the programme.

2.4 ACADEMIC BASIS FOR THE RESEARCH

Education Bulletins (eg. Ref. SS 3/88) appear annually after the final matric examinations highlighting mostly problems experienced with particular question papers. The attention of subject heads is drawn to specific problem areas within their subject. It is from these bulletins that I became aware of the inability of pupils to cope with higher-order thinking skills required for Biology on the Higher Grade. The problem appeared to be concentrated on the Physiological aspects of the human body. This, gathering from the reports, is due largely to misconceptions held by teachers as well as poor instructional techniques employed by teachers.

Barrass(1984:201) illustrates the harm done by some established

textbooks of Biology which contain obvious mistakes. He lists from various books specific concepts which are misrepresented and perpetuated by teachers in this same mistaken form. This is largely due to teacher misunderstanding of the concepts on their part. How can the teacher then recognize these misconceptions if that is the way in which they have learnt these concepts? This further stimulates the interest in promoting a broader and more in-depth understanding of the various biological concepts. In this way it can be be ensured that our pupils understand the various concepts and should they become teachers of Biology they be able to identify suspect definitions and descriptions and be able to verify the validity of the statements. Barrass also mentions Homeostasis specifically as a problem area (Ibid:204) indicating that students confuse the process of homeostasis with the homeostatic mechanisms involved in the maintenance of body homeostasis. A weakness in his article, however, I find that he mentions the misconceptions but does not rectify or forward the correct or accepted definitions or descriptions.

Homeostasis was among the concepts which Simpson and Marek (1988) investigated in pupils of small and large high schools. The graph depicting the responses of pupils (Fig.2 in their article) shows a high peak at the 'no response' end and nothing at the 'sound understanding' end. Checking my Graphs in Chapter 4, this same trend can be seen across the board for Experimental Group 1 and the Control Group. Experimental Group 2 had a greater response at the

positive end.

The following phrases are cited from **Brenner and Stein** (1987) to show the real predicament in which Human Physiology finds itself. With due respect to the wonderful progress made in the field the following remains uncertain:

Marsden and Skorecki's research paper includes the following statement: "An adaptation **OR** resetting of afferent signalling mechanisms occurs in states of chronic ECF (extra-cellular fluid) volume overload **OR** depletion, creating a system that is stable at multiple levels of salt balance" (p.24)

Nadler and Brenner ends their paper (p.124) : "The physiologic importance of these findings remain uncertain"

Levinsky et. al. (p.177-8) states that: "Available evidence is **not yet complete or consistent enough** ... we **suggest** that the K.K.-system **may** have two relevant renal functions. .... As more complete understanding of the role of renal K.K-system should become possible..."

Kamal Badr (p.372) : "Despite the **lack of more convincing evidence** for capillary wall defects...." and (p.431) "Despite this extensive experimental literature, there is not yet convincing evidence that these agents are effective in humans."

[Bolding and underlining in the above paragraph is my own; a way of highlighting the uncertainty and gaps which is prevalent in this area of physiolgy]

These are but a few selected extracts from the this collection of papers of medical research in the field of homeostasis. The manpower seems to be lacking to facilitate more speedy progress in this field. It is highly probable that more pupils would be entering this field of study at higher levels if it were to be presented more practically and relevant to their very existence. A better understanding of the underlying principles of homeostasis and its practical relevancy should be of primary importance in the teaching of this aspect of Biology.

Cannon (Langley,1973:242-3) expresses the opinion that an attempt at present [1925] to develop an elaborate and intricate conception of the interrelatedness of the endocrine glands would be altogether too premature and might be quite misleading since the necessary facts are not at hand. Since his investigation much research has been done in this field. One such investigation is contained in the work done by Cross (Ibid, 157-188) on the mechanisms of operation and functions of the hypothalamus. This describes in-depth the role it plays in homeostasis where hypo- and hyperglycaemia would stimulate or inhibit the hunger and satiety centres respectively. These processes, of course, are antogonistic in nature, as are many other homeostatic control mechanisms. The effects of oestrogen and progesterone on hypothalamic neurones are also explored. As I have indicated earlier, a holistic approach to

studying homeostasis in essential. As Cross (Ibid:187) puts it: "The control systems depicted in Figs. 4, 6, 7, and 9 are certainly far more complicated than these diagrams imply. None are closed systems, for in every case there are other nervous or humoral influences that can be shown to operate and which can alter the output of the sytem." The paper was written in the mid sixties by experienced physiologists, yet Cross (Ibid: 157) deliberately ignores going into too much detail of the hypothalamic morphology. The rest of the paper, however, maintains a very high academic level that only physiologists would understand. What I am trying to drive at here is the differentiation which can be made under certain circumstances to avoid unnecessary detail. In our current Biology curriculum we are often bogged down with avoidable detail, particularly in the field of Botany.

In 1929 already Cannon (Ibid:251) had defined homeostasis the way we teach it today. Yet a great aura of mystique still surrounds this concept. It has become apparent, from conversations with, questions from and statements by many teachers at meetings, conferences and workshops, that Homeostasis is still an area of difficulty. Misconceptions or alternative conceptions held by teachers of Biology are transferred to pupils. These pupils find it difficult to unlearn these alternative conceptions and perpetuate these views if they in turn become teachers of Biology.

If pupils possess some cognitive skills it would enable or urge them to question vague and cloudy conceptions. This could stimulate researsch by both teacher and pupil. Pupils often do not know whether they understand something or not. Often teachers do not have the professional resources to determine to which degree his/her pupils understand a specific piece of work.

Machin (Langley, 1973:421) asserts that Formal Feedback Theory is a happy hunting ground for mathematicians, their works being embodied in books more notable for rigour and completeness than for comprehensiblity and immediate usefulness. We do not want the same situation to prevail in the books of Biology and Physiology and therefore we, bio-physiologists, should pursue the knowledge to improve on the state of the mathematicians. Machin sees the work of the engineer and biologist largely as complementary; the engineer's work being synthetic and that of the biologist analytic. In relating properties to structure, the biologist frequently makes use of models, be it conceptual, mathematical, schematic, or even actual. Feedback theory can often help him to relate properties and model. The physiologist, he claims, is really interested in models of a higher order; he needs to reduce the system under study to a set of interconnected simple 'black boxes'. He realises the need of interconnecting or interrelating the system, thus the need for integration of the information.

Much more recent work done in this field includes an investigation

by Timo-Iaria (NIPS, April 1990:46-49) in which he investigates the presence and functions of Glucoreceptors. A very detailed scientific physiologic study describes the control of glycaemia and feeding behavior. The investigation is aimed at finding out at which levels and under what conditions glucose is required exogenously and describes the role played by insulin as well as the hypothalamic function. This article proved to be of particular interest to me since I am very interested in the physiology of hunger (cf. work of Cross above).

Kawo et. al. (Lancet,Aug 25 1990:454-457) investigated the specificity of hypoglycaemia for cerebral malaria in children,but states that the condition should be sought in all severely sick children. His article ends as follows:

> "Hypoglycaemia was associated with a poor prognosis even after glucose infusion; 75% of all the hypoglycaemic children in this study died... Much of this mortality rates could be reduced if the attendant hypoglycaemia could be corrected. It requires constant vigilance for hypoglycaemia and its correct management."

If we assume that these children were cared for by doctors and nurses trained in their jobs the level of understanding of the implications of hypoglycaemia seems limited. From personal experience, being a chronic anaemic-hypoglycaemic person, I can vouch for the experience of being 'seriously ill' under conditions of hypoglycaemia.

Reversing that condition by consumption of instant-high-energy

foods 'takes the troubles away'. For the lay person this implies that s/he should be aware of varying physiologic patterns in children and not refuse to feed 'a child that eats too much therefor he remains thin'. For the active sports person it means watching what you eat so that you have enough energy to carry you through the exercise. And last, for the health-conscious/ figure-conscious person it means that they could learn the truth about what they eat and that avoiding some foods is not necessarily good for their well being.

The understanding of the above can only be achieved by proper instruction . Because of the 'product-pushing' via the media the lay person, and often the half-educated (in this field), literally BUY these stories. What I try to make clear with the above information also is the situation we are in today. In spite of all the work being done and all the new information becoming available we are not making any progress to improve the attitudes in schools.

More and more extra-educational bodies such as large corporations and chain stores are taking an interest in the education of the man-in-the-street. The information is becoming more and more technical. If the pupils, at least, are equipped to enlighten the elders who did not have adequate schooling society will be getting somewhere in their efforts to educate the masses. An example of such educative material, particularly concerning my topic, has been

issued by the PICK 'N PAY chain. Appendix 8.9 is proof of this avenue taken in society.

The issue of learning factual content needs the attention. Soar (1972:516) raises the question whether an intermediate level of teacher-centeredness or pupil-centeredness might have led to more favourable attitudes and greater cognitive growth than either extreme did. If there is a balance in the 'directed-indirectedness' of the teacher a moderately ascending line should be obtained instead of the curve currently produced. Soar has found a current non-linear relationship which implies that as teacher 'indirectedness' increased beyond a certain point the progress of the learner seemed to drop, at first gradually and then much more sharply. He cites many other studies in his paper which I do not see the need to discuss here but the findings backs the suspicion that children learn better and perform better when they are left free to explore but yet feel that they have the back-up of the teacher if needed. This would require much preparation on the part of the teacher, but pays off in the end. The activities which pupils are engaged in during 'self-exploratory' or 'heuristic' approaches are by no means unstructured. Much preparations need to be done by the teacher to ensure that the pupils learns the heuristic which he intends for his pupils to acquire or that he has a good set of instructions and activities during a 'self-exploratory' laboratory experience to make his activity meaningful.

It is important then that first the teacher be mentally, both attitude and information, well equipped to handle a new approach to his teaching. Second, it is important that the introduction of this new approach be done in such a way as not to drive the pupils away but to attract them to a new method of learning. If the teacher is prepared and willing to sacrifice the time to structure his activities learning could be a pleasant experience for the child.

Leaning does not have to be painful as many people believe. The current saying: "No Pain - No Gain" is still very popular with many teachers. It is time to explore the avenues available which makes learning a more pleasant experience.

What can be done in the near future to aid a pleasant transition to a cognitive approach to teaching in high schools will be discussed in Chapter Five.

Important for the reader to note at this stage is the work of John Holt on 'How Children Fail'. An excerpt from his book (Holt,1982:2), would hopefully stimulate any teacher and parent to avoid creating the situations in children described below:

["They" below refers to the students]

"They are afraid, above all else, of failing, of disappointing or displeasing the many anxious adults around them, whose limitless hopes and expectations for them hang over their heads like a cloud.. They are bored because the things they are given and told to do in school are so trivial, so dull, and make such limited and narrow demands on the wide spectrum of their intelligence, capabilities, and talents. They are confused because most of the torrents of words that pours over them in school makes little or no sense. It often flatly contradicts other things they have been told, and hardly ever has any relation to what they really know- to the rough model of reality they carry around in their minds."

2.5 CLARIFYING SOME CONCEPTS

According to Novak (1977:18) :

FACTS are records of events that occur in the world.

CONCEPTS describe some regularity or relationship within a group of facts

THEORIES serve to link concepts or suggest ways in which concepts may be related.

Ruggeiro (1988:1) defines thinking the way he uses it in his book
THINKING embraces only a purposeful mental activity over which a person exercises some control

Nickerson defines the following terms in the way he uses it:

REASONING encompasses many of the processes we use to form and evaluate beliefs about the world, about people, about the truth or falsity of claims we encounter or make. (1986:1)

KNOWLEDGE is information that we have stored in our heads. (1986:15)

The chosen definitions of these concepts clarified above are used in much the same way in this paper.

2.6 CONCLUSION

To make the distinction between Education and Academic as was done in 2.2 and 2.4 is such a superficial and artificial system, but I deemed it necessary in order to structure this chapter. However, the article by Soar discussed above fits well under 2.2.1 as well. This article by Soar (1972)investigates teacher behavior related to pupil growth. The teacher behavior he explored was the 'directedness' or 'indirectedness' of the teacher. He discovered that the more indirect the teacher was beyond a certain point with content subjects the less learning occurred. With vocabulary the results was a little better but the greatest success with teacher indirectedness was seen in the growth in creativity of the pupils.

Creativity is an essential part of cognitive development. If one cannot learn to be creative, which is supposed to be the easiest, free-reign terrain, how can one master such concepts as those related to homeostasis which are more formal and set issues. The information furnished above is an attempt to spell out the existing state of affairs in the field under investigation. Although at some places the information supplied seems somewhat removed from the teaching situation it has an immediate bearing on teaching. It is, in my opinion, the state of the primary and secondary school education which determines the state of affairs outside of the

school situation. This, then, creates the vicious cycle of a 'poorly' developed teacher, produced by the existing situation, leading his pupils into yet another mystical era of Biological concepts.

A discussion of the Theories and principles which impact the investigation follows. The work of Piaget, Bruner, and Feuerstein will enjoy some attention and also some Heuristically oriented approaches to teaching thinking.

C H A P T E R 3

THEORIES AND PRINCIPLES WHICH IMPACT THIS INVESTIGATION

3.1 THE WORKS OF PIAGET

3.1.1 PIAGET'S VIEWS ON KNOWLEDGE AND INTELLIGENCE

The major questions which Piaget tries to address in his works concerns how the growing child adjusts himself to the world in which he lives and how we are to account for the constant recurrence of what, to the rational adult, seem extreme instances of maladjustment (Helmore, 1969: 2). Being a Zoologist by training, an epistemologist by vocation, and a logician by method (Ibid: 3) I was naturally intrigued by Piaget's approach and his views on how children learn science. This interest motivated my exploration of his works.

Piaget defines intelligence as "the state of equilibrium to which tend all the successive adaptations of sensori-motor and cognitive nature, as well as all the assimilatory and accomodatory interactions between the organism and the environment." (Ibid: 46). He asserts that knowledge is essentially active. To know is to assimilate reality into a system of transformations. The transformational structures of which knowledge consists are not

copies of the transformations in reality, but simply isomorphic models among which experience can enable us to choose. (Piaget, 1970: 15). The **accomodation** that occurs is always the accomodation of a scheme of **assimilation** (Furth, 1969:145). He believes that the basic unit of knowledge is something much more complex than a sensation or atomic effect. Even simple knowledge presupposes a prior (formal) conceptual element, typically of the logico-mathematical type.

Experience involves the assimilation of the sensation or sense data to an earlier conceptual scheme or concept, the assimilation being equivalent to the judgment of the rationalist. The basic epistemological unit is thus a judgment or an equivalent with a cognitive complexity involving rules, categories, schemas, and principles. Since the schemas, concepts, etc. are related to each other in a complex formal-structural way, they have a holistic character (Kitchener, 1986: 71).

3.1.2 PIAGET'S STAGES OF DEVELOPMENT

The equilibrium referred to above is attained and maintained through the various stages of development which Piaget identified. These stages are described in detail in Piaget (1972: 19 - 46). Helmore, (1969:8 - 12) presents the stages in an illuminating way,

and I show the following outline from his presentation:

Stage 1: SENSORI-MOTOR ; Age : 0 - 2 years

Characterised by motor actions accomplished by trial and error.

Stage 2: PRECONCEPTUAL ; Age : 2 - 4 years

Characterised by the development of symbolic and preconceptual thought. Preconcepts are the notions which the child attaches to the first verbal signs he learns to use. No inductive or deductive arguments as yet. Transductive, i.e. from particular to particular, arguments occur.

Stage 3: INTUITIVE ; Age : 4 - 7 years

The child starts to develop a mechanism of 'thinking', but rather egocentrically, slowly displacing the centre of his thought process to the external environment.

THE ABOVE PHASE ARE OFTEN GROUPED TOGETHER AS THE PRE-OPERATIONAL STAGES.

Stage 4: CONCRETE OPERATIONS ; Age : 7 - 11 years

Characterised by operational groupings of thought concerning objects that can be manipulated through the senses. Identification of reversibility and the development of logical thought follows. Concrete concepts in the system

include: classification, seriation, and the number system.

Stage 5: FORMAL OPERATIONS ; Age : 11 -

This coincides with the adolescent period ! Completion of reflective thinking occurs as the child is no longer deterred by perception nor limited by the concrete situation. Four major abilities are distinguished here:

a) The ability to reason on relations between propositions

b) The ability to consider and use all possible disjunctions and combinations

c) The Ability to use inversion and reciprocals in a single system

d) increased understanding of action and reaction.

About the ages 11 - 12 the child gradually becomes aware of the definitions of concepts he is using, and acquires a partial aptitude for introspecting his own mental experiences. A certain awareness of implications is created in his mind, and this renders these experiences reversible, removing at least such contradictions as are fruit of condensation (Piaget,1928:243). He is gradually moving away from concrete situations as a basis for his mechanism of operation and becomes increasing adept with the more formal modes of thought.

It is particularly the last two stages which had a great influence on the development of the investigation. All the subjects of the investigation are pupils older than 11 years who should be at the

Formal Operations level. Yet, upon entry into the high school, these pupils seem to be at a level of development midway between the last two. It is this observation that led to the closer observation of pupils. In an attempt to find out why they are not at the documented level of development corresponding to their age deficiencies in their mental models became evident. It appeared that most of the pupils were still firmly embedded in the Concrete Operations Mode rather than the Formal. The pupil thus needs all the help s/he can get to aid his transition from the Concrete to the Formal Operations stage.

3.1.3 CLARIFYING SOME CONCEPTS

AN OPERATION is an action that can be internalised, is reversible and supposes some conservation, i.e. some invariance. It does not exist in isolation (Piaget, 1970: 21)

A STRUCTURE is a totality, a system governed by laws that

a) apply to the system as such and not only to one or other element in the system

b) are laws of transformation, not static in character and

c) causes the system to be self-regulating (Ibid: 22)

A SCHEME is recognised as whatever is repeatable and generalizable in an action. A logic of schemes exists in an

individual (Ibid: 42)

3.1.4 The Significance of Piaget's Work

Like Piaget's investigation, this investigation has little interest in group averages. Similar to Piaget emphasis is on what is **common** to all subjects at the **same** level of development (Ibid).

Piaget's work enabled me to realise that most of the school pupils were not performing at the level which they were supposed to be. This was an important discovery. The assumption was that these pupils were stuck somewhere on the periphery of formal operations in their academic battles, unable to escape from the firmhold of the concrete operations which they were so comfortable with. Teachers often fail to see the need of these pupils for assistance to get on with Formal Operations and leave them to drown in their limited world.

3.2 THE WORKS OF JEROME BRUNER

Allow me to start this section with the delightful note that I have had the honour of meeting and speaking with Jerome Bruner on October 31 1990 at the Gutman Conference Centre of Harvard University. Bruner's teacher was a biologist. In his many works he often draws examples from this field, which makes his work more

relevant and applicable to this investigation. He also draws from the works of an endocrinologist, Rountree (Bruner, 1983:132-3). How this influenced his works, his patterns of thinking, is not clear. His work has direct relevance to this investigation. Many of the examples he uses are from the sciences, and from that a large percentage from Biology.

3.2.1 Bruner's Views on Education and Learning

Bruner (1977:9) considers the cultivation of excellence as the most general objective of education. Learning should serve us in the future; not only take us somewhere but allow us to go further more easily (Ibid:17). He sees progress in this field as being hampered because "Our insights into mental functioning are too often fashioned from observations of the sick and the handicapped. It is difficult to catch and record, no less to understand, the swift flight of man's mind operating at its best." (Bruner,1963:15) . The excellence referred to above by Bruner refers not only to the schooling of the better student but also to helping each student achieve his optimum intellectual development.

Bruner defines four basic features of the process of education as vital to the success of learning. First, he maintains that the teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the centre of the classic problem of transfer. Second, in his opinion the readiness for learning is

being misinterpreted. He asserts that experience over the past decade points to the fact that our schools may be wasting precious years by postponing the teaching of many important subjects on the ground that they find it too difficult (Bruner, 1977:12-13). Third, the nature of the intuitive needs attention. On this he notes the following:

> "Intuitive thinking, the training of hunches, is a much neglected and essential feature of productive thinking not only in formal academic disciplines but also in everyday life. The shrewd guess, the fertile hypothesis, the couragous leap to a tentative conclusion - these are the most valuable coin of the thinker at work, whatever his line of work." (Bruner,1977:14)

The last point relates to the desire to learn and how it may be stimulated. Interest in the material to be learned is the best stimulus rather than such goals as grades or later competitive advantages (Ibid).

Bruner asserts that most human beings are unaware of how much information they actually possess on a given subject. When information is organised in terms of some Generative Model, it turns out that there are many other things that follow from it in a way that verges on redundancy (Bruner,1971:93). In this regard Bruner considers discovery central to learning and he suggests that the teacher teach discovery. Citing Bruner (1971:72) :

> "Discovery teaching generally involves not so much the process of leading students to discover what is "out

there", but rather, their discovering what is in their own heads. It involves encouraging them to say, Let me stop to think about that, Let me use my head, Let me have some vicarious trial-and-error."

Emphasis on discovery helps the child to learn the varieties of problem solving, of transforming information for the better use and helps him to learn how to go about the very task of learning (Bruner,1963:87). He cites from the Autobiography of Lincoln Steffens who writes about his undergraduate studies implying that too much attention was paid to learning what was known and too little to what was not known (Ibid:92). Bruner distinguishes two types of teaching, viz. that which takes place in the expository mode which is determined by the teacher as expositor and the student the listener. Second, that which takes place in the hypothetical mode where teacher and student are in a more cooperative situation. The student is not a bench-bound listener, but participates in formulation and at times plays a principle role in formulation (Ibid:83). He sees four major benefits from the hypothetical mode:

1) An increase of intellectual potency
2) A shift from extrinsic to intrinsic rewards
3) The learning of heuristics of discovery
4) The aid to conserving memory.

I would like to cite the following in conclusion to this paragraph:

"... to the degree that one is able to approach learning

> as a task of discovering something rather than 'learning about it', to that degree there will be a tendency for the child to work with the autonomy of self-reward or more properly, reward by discovery itself." (Ibid:88)

3.2.2 Bruner's Views on Learning and the Intellect

Bruner feels that the most pervasive feature of human intellect, perhaps, is its limited capacity at any moment for dealing with information (Bruner,1971:4). He further suggests that man's intellect is not simply his own, but is communal in the sense that its unlocking or empowering depends upon the success of the culture in developing means to that end (Bruner,1971:7 ; Bruner, 1973:437) The use of amplifiers of mind, i.e. that which strengthens mental ability and agility and aids in the acquisition of skills, requires a commonly shared human capacity, and each society fashions and perfects this capacity to its needs. The amplifiers relates to action, the senses, and thought processes (Bruner,1971:83; cf. Bruner,1973:443). To accomplish this amplification (Bruner,1971:6)

> "We organize experience to represent not only the particulars that have been experienced, but the classes of events of which the particulars are exemplars. We go not only from part to whole, but irresistably from the particular to general. At least one distinguished linguist has argued in recent time that this generic tendency of human intellect must be innately human, for without it one could not master the complex web of categorical or substantive rules that constitute the syntax of language."

According to Bruner the act of learning comprises three almost simultaneous processes. First, **acquisition** of new information.

Often information that runs counter to or is a replacement for what the person has previously known implicitly or explicitly. Second, **transformation** which is the process of manipulating knowledge to fit new tasks. We learn to 'unmask' or analyze information and to order it in a way that permits extrapolation or interpolation or conversion into another form.

Third, **evaluation** which implies checking whether the way we have manipulated information is adequate to the task (Bruner, 1977:48-49). Bruner recognizes three different systems, partially translatable one into the other, for representing reality. One is through **action** the concrete; the second through **imagery** - the ikonic; and the last through **symbols** - the symbolic (Bruner,1971:7-8; 1973:325-329). The three stages of symbolic reference which he identifies are:

1) the ostensive mode in which an object referred to is pointed at without any further elaboration

2) labelling being the attachment of a name or label to the object without any verb or action words

3) sentential placement when the object referred to is used in a complete sentence.

The 'labels' referred to in (2) above would identify a schema (not to be confused with the 'scheme' of Piaget). The information that one acquires from "that integrated, organized representation of past behavior and experience" (Bruner,1973:xviii) is organized into schemas in the mind and a schema can **only** operate when called into

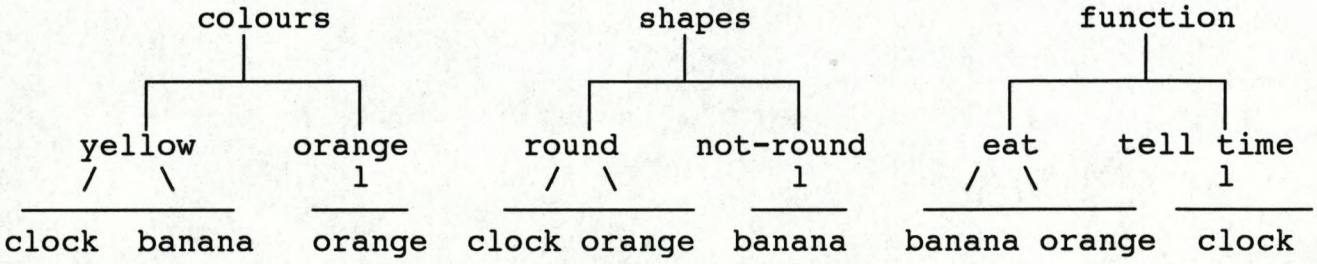
play. Language affects cognition **only** if linguistic coding occurs, i.e only if the stimulus is given a verbal representation.

Linguistic encoding may be **inappropriate** to the task at hand if the labels attached to it do not encode all the information or the labels cut the domain in places other than the task demands. The degree to which a label encodes all the information depends not only on the task at hand but also on the array of stimuli. A given label becomes ineffective in distinguishing a given stimulus if it must be discriminated from others to which the name could also apply (Bruner,1971:40-42). This means that labels assigned to specific sets of information should be suitable to distiguish that information from any information previously learned.

Assigning labels to remember information may require the use of mediators of which Bruner recongizes three kinds. Of particular interest is the **GENERIC** Mediators which assigns a label superordinate to information whereas **THEMATIC** Mediators includes the information in some kind of story. The best mediator, though, he suggests, is that which the **CHILD DEVISES** himself (Bruner,1963:95). This will enable him to remember why he had assigned a specific label to the set of information and thus he will remember the information when asked about it.

Organizing the labels in a hierarchical set was investigated using a number of words which had to be remebered. The following

superordinate categories were used as labels and objects or attributes placed within each category (Bruner,1971:42; 1973:344)



This shows principles of inclusion and exclusion and as Bruner holds "A concept... is defined as much by what it excludes as what it includes, by its contrast class" (Bruner,1971:43).

To accomplish this skill of labelling correctly, choosing a specific superordinate, requires skilled action. Skilled action, on the other hand, requires recognising the features of the task, its goal and the means appropriate to its attainment, a means of converting information into appropriate action, and a means of getting feedback that compares the objective sought with the present state attained (Bruner,1971:112)

3.2.3 Bruner and Concept Formation

As stated above concepts are defined as much by what they exclude

as by what they include. Certain attributes determines whether something would be excluded or included. Bruner (1967:41) distinguishes three types of concepts. (See also Bruner, 1973:xiv)

1) Conjuctive concepts which are defined by the **joint presence** of the appropriate value of several attributes (eg. all cards containing red circles)

2) Disjunctive concepts which constitutes any combinations of or single attribute of a certain set. (From eg. above - any card with red or any card with circles)

3) Relational concepts in which specifiable relationships between defining attributes can be detected. (From eg. above - cards with the same number of borders and figures or with the number of figures less than borders)

The development of configural attributes is best illustrated by a concrete example. In learning microscope techniques in histology a student is told to look for the corpus luteum in a X/S of a rabbit ovary. He is told with respect to its defining attributes that it is **yellowish, roundish of a certain size** relative to the field of the microscope, etc. He would find it this way. On a next occasion he would still be scanning the attributes. As he becomes accustomed to the procedure and the kind of cellular structure involved, the corpus luteum begins to take on something classically referred to as a Gestalt or configurational quality. He no longer goes through the slow business of checking size, shape, color, texture, etc. Indeed, corpus luteumness appears to become a property or attribute in its own right (Bruner,1967:46).

From an experimental point of view concept attainment seem to be an

intrinsically unanalyzable process (Ibid:50). The learner in which concept attainment is studied is observed as he tries to externalise his process of concept attainment. From many subjects observed the researcher would make inferences and try to find regularities in the processes. These regularities in decision-making is referred to as strategies. A strategy refers to a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives. The following is a list of some of the objectives of a strategy:

a) To insure that the concept will be attained after the minimum number of encouneters with relevant instances.

b) To insure that a concept will be attained with certainty, regardless of the number of instances one must test en route to entertainment.

c) To minimise the amount of strain on inference an memory capacity while at the same time insuring that a concept will be attained

d) To minimise the number of wrong categorizations prior to attaining a concept (Bruner,1967:54).

3.2.4 The Importance of Bruner's work

Since in the above many biological examples were used in the explanation and elucidation of the principles and theories which Bruner hold I do not think it is necessary to go into detail here is the above work spells out clearly how useful his work is or can be to Biology teachers.

The approach to teaching during this programme, and my teaching in

general, is geared toward discovery teaching as opposed to transmission teaching. Learners do much of their learning by discovery rather than being told the facts or options.

3.3 FEUERSTEIN'S COGNITIVE OPERATIONS APPROACH

To elucidate Piaget's work as a Cognitive Operations approach I will cite part of the Foreword to Feuerstein (1980:viii) which was written by Nicholas Hobbs:

> "Inspired by 'our two great masters of the Genevan School, Prof. Jean Piaget and Prof Andre Rey, Feuerstein initiated work leading to 'a radical shift from a static to a dynamic approach in which the test situation was transformed into a learning experience for the child.."

This description indicates the value of the work done by Piaget, and shows how Piaget's studies have pioneered focus on the child's learning experiences in education research.

3.3.1 FEUERSTEIN'S VIEWS ON LEARNING AND INTELLIGENCE

Feuerstein believes that the human organism is open and amenable to change. This demands a very different method of assessment and evaluation. The following sums up his basic philosophy:

> "...Modifiability is considered to be the basic condition of the human organism, and the individual's manifest level of performance at any given point in his development cannot be regarded as fixed or immutable, much less a reliable indicator of future performance. Tangible expression of this viewpoint is evident in the rejection of I.Q. scores as reflective of a stable or permanent level of functioning. Instead, and in accordance with the open systems approach, intelligence

> is considered a dynamic self-regulating process that is responsive to external environmental intervention." (Feuerstein,1980:2)

Mediated Learning (MLE) is an important input into this open-ended system, aiding the changes in cognitive growth. MLE is facilitated by a Mediating Agent which is usually a parent, sibling, or caregiver (Ibid:16). He defines MLE as "the way in which stimuli emitted by the environment are transformed by a 'mediating' agent (Ibid:15). Guided by his intentions, culture, and emotional involvement the Mediator selects the stimuli which are most appropriate. He therefor considers MLE as the most important determinant of intelligence. With the correct Mediation, irrespective of the stage or age of development he contends that cognitive dysfunctions may be reversed. The cognitive dysfunctions are a direct result of a lack of MLE (Ibid:88). MLE forms the theoretical foundation of the belief in the reversibility of deficient cognitive functions processes under specified conditions of intervention (Ibid:17). The greater the quantity and quality of MLE the higher the capacity of the organism to become modified by direct exposure to stimuli.

3.3.2 COGNITIVE DEFICIENCIES

Feuerstein recognizes three phases in any cognitive operation, viz. input, elaboration, and output. The dysfunctions or lack of facilities referred to above may be experienced at any of these phases in any combination.

At the **INPUT** phase Feuerstein identifies the following deficiencies as a result of a lack of MLE:

a) blurring and sweeping perception which manifests itself in ill defined parameters and inability to delimit a field

b) unplanned and impulsive exploratory behavior

c) lack of receptive verbal tools and concepts

d) lack of spatial and temporal orientation

e) lack of conservation of constancies

f) lack of precision and accuracy in data gathering

g) inability to consider two sources of information simultaneously (Feuerstein (1980:73)

At the **ELABORATIONAL** phase he recognizes

a) inadequacy in experiencing the existence of a problem

b) inability to select relevant information

c) lack of spontaneous comparative behavior

d) narrowness of mental field

e) lack of or impaired need for summative behavior

f) difficulty in projecting virtual relationships

g) lack of orientation toward need for logical evidence in an interactional modality with one's objectal and societal environment

h) lack of interiorization of one's behavior

i) lack of inferential-hypothetical thinking

j) lack of strategies for hypothesis testing

k) lack of planning behavior

l) non-elaboration of certain cognitive categories

m) episodic grasp of reality (Ibid:73-74)

At **OUTPUT** phase he recognizes

a) egocentric communicational modalities

b) blocking

c) trial-and-error responses

d) lack of verbal tools for communicating adequately elaborated responses

e) deficiency of visual transport

f) lack of need for precision and accuracy in communicating one's responses

g) impulsive acting out behavior, affecting the nature of the communication process (Ibid:74)

Feuerstein also takes the structure of intelligence of the retarded performer into account when analysing it and accepts that the motivational aspects of the functioning of the retarded performer is influenced by

a) his cognitive structure and

b) environmental and cultural dimensions which determines his needs system i.e. the necessity of his cultural redevelopment as determined by his life in the modern, technological world.

3.3.3 Feuerstein's Instrumental Enrichment Programme (FIE)

In his attempt at reconstruction of the cognitive structure Feuerstein had developed the FIE Programme which is aimed at assisting the retarded performer achieve his optimal cognitive levels. The term 'retarded performer' is used to convey the idea

that what is retarded is the individual's manifest cognitive behavior as reflected in his performance and not his **capacity** (Feuerstein,1980:xviii). The programme aims at changing the overall cognitive structure of the retarded performer by transforming his passive and dependent cognitive style into that of an autonomous and independent thinker. FIE is addressed not to any specific skill or content area, but to the process of learning itself (Ibid). The LPAD (Learning Potential Assessment Device) is designed to assess learning potential by producing cognitive changes during the test process and is used as a basis for the FIE programme (Nickerson et.al.,1985:148).

Learning Potential is the susceptability to change via MLE. The programme operates on the dynamic assessment of the retarded performer along the guidelines given in paragraph 3.4.2. Using the LPAD, MLE is brought about by the Mediating Agent and a continuous monitoring of the cognitive progress of the 'retarded performer' is followed. Being capable of displaying or performing certain cognitive operations the Mediator assesses the cognitive growth of the individual.

The structural changes occurring refer not to isolated events, but to the organism's manner of interacting with, i.e. acting on and responding to, sources of information (Feuerstein,1980:9). The main attempt of the LPAD is the reconstruction of the cognitive structure. It's analysis of cognitive behavior is done in

accordance with a **COGNITIVE MAP.** A Cognitive Map represents a set of parameters in terms of which to analyze, catagorize, and order mental acts (Nickerson et.al.,1985:152) He identifies seven parameters of the cognitive map viz. Content, Operations, Modality, Phase, Level of Complexity, Level of Abstraction, and Level of Efficiency. (Feuerstein, 1980:105-109 ; Nickerson et.al.,1985:152)

3.3.4 The Goals of the FIE Programme

A deeper understanding of the widely used constructs such as intelligence and capacity is gained by this approach. It is also source of direct and immediate help for individuals whose current level of functioning by become the source of decisions whose far-reaching effect may be crucial for their destiny (Feuerstein, 1979:330)

The six subgoals of the programme are:

1. Correction of the deficient functions that characterize the cognitive structure of an individual
2. Acquisition of certain basic concepts, labels, vocabulary, operations, and relationships that are necessary for the performance of cognitive tasks.
3. Production of intrinsic motivation
4. Production of reflective, insightful thinking by the student regarding his successes and failures
5. Creation of task intrinsic motivation
6. Instillation in the learner of a perception of himself as an active generator of knowledge and information rather than a passive recipient and reproducer of it. (Nickerson et.al.,1985:153)

As part of the Appendix in Feuerstein (1980:405-410) a summary of the characteristics of the programme is illustrated very clearly and simply, addressing about 30 (thirty) aspects of the programme.

3.3.5 THE IMPORTANCE OF FEUERSTEIN'S WORK TO THE INVESTIGATION

The clear scheme of Cognitive Defiencies put forward by Feuerstein has enable the identification of major basic skills which pupils lacked. This has facilitated a narrowing of the field in the search for some 'remedial action' of the current situation. The three deficiencies identified to concentrate on, are underlying skills. If these are addressed effectively and corrected, would facilitate easier access to, and maybe automatic, correction of the higher order skills.

From the programme also came ideas of how to address these Cognitive Deficiencies. It is particularly the views on Learning and Intelligence and a study of the Instrumental Enrichment Programme that enabled the speedy development of a programme to suit the needs of the pupils involved in the investigation. Using some aspects of the Cognitive Map, which was rather incidental, in the exercises with which the subjects were confronted resulted in a fairly comprehensive 'test' for the deficient Cognitive Operations.

3.4 THE HEURISTIC APPROACHES

This approach is based on equipping the problem-solver with appropriate know-how in the form of heuristics rather than facts (Nickerson et.al.,1985:190).

3.4.1 WHAT ARE HEURISTICS ?

The word 'heuristic' is derived from the Greek heuriskin meaning "serving to discover". Polya (1957) used the word to connote inductive and analogical reasoning leading to plausible conclusions (Nickerson et.al.,1985:74). The term has more recently been used by researchers in the field of machine intelligence to distinguish between two types of procedures. One, the algorithm, is a step-by-step prescription for accomplishing a specific goal. It has, by definition, the guarentee to accomplish what it is supposed to accomplish. A heuristic, on the other hand, "is only a good bet, a procedure believed to have a reasonable likelihood of yielding a solution." (Ibid).

A heuristc procedure is in essence a non-rigorous method of achieving solutions of problems. While it often leads to solution, it offers no guarentee of doing so (Bruner,1977:43) [See also 3.2.4 above].

3.4.2 WHY HEURISTICS ?

Because professions remained unchanged for a long time stored knowledge could be passed on from generation to generation. Consequently Rubinstein (Tuma, 1980:25) suggests that in the future high school and college graduates will have to be retrained more than once in their life span.

In his book The Third Wave, Alvin Toffler describes the changes in society's needs which concurred with changes in the economy. The reduction of the extended family of the First Wave to the nuclear family of the Second Wave and eventually to the single's society of the Technocratic era, the Third Wave. The needs and values systems in society changed. Toffler tried to prepare the human race in his Future Shock about twenty years ago, still we are not at all well prepared to face the Shock.

Toffler's 1984 Previews and Premises (p44-46) speaks of the retooling of the mind as follows:

> "To be hard-nosed, we have to face the fact that many of these laid off workers will not be reabsorbed into their old jobs - or any jobs in the Second Wave sector of the economy - and that most of these workers are unequipped for the new jobs opening up in the Third Wave sectors. This means one of two things: retirement or retraining. ... The problem is that when I speak of training or retraining for jobs in the Third Wave industries, I'm speaking of more than just simple occupational skills. The new industries operate in, or create, a new culture as well - they bring new values; they reward different attitudes and life styles."

Tuma and Reif (1980:ix) feel this need for change and express in their preface their concern: " ...there is an increasing need to

teach improved problem solving skills to students who must be adequately prepared to cope with a world characterized by growing complexity, rapid change and vastly expanding knowledge." Compare also McTighe and Schollenberger's comments on the increase in available knowledge (Costa,1985:4).

3.4.3 POLYA'S HEURISTIC APPROACH

Polya's work grew out of a desire to teach students that which would be of general use to them in solving different kinds of mathematical problems. Being a mathematician his work is largely math oriented but the general principles can be transfered to other subject fields. Polya identifies four phases of problem solving and presents heuristics to work throught these phases.

1. Understand the Problem
2. Devise a Plan. This involves formulating a general strategy, not a detailed proof.
3. Carry out the plan
4. Look back i.e. check your results (Nickerson et.al., 1985:75)

Heuristics to understand the problem are the following:

* Make sure that you understand the **unknown**, the **data** and the **conditions** that relate to the data.
* Make sure you understand the nature of the goal state, the **initial** state and the **permissible operations.**
* Draw a graph or diagram and introduce suitable notation
* If one way of representing a problem does not lead to a solution, try to restate or reformulate the problem.

(Nickerson et.al., 1985: 75-76)

Each of the above heuristic steps is discussed in detail and the same is done for the other three phases. Most of the heuristic approaches follow the basic example of Polya and below I will discuss some of the programmes to teach thinking skills using heuristic approaches.

3.4.4 PROGRAMMES DEVISED TO TEACH THINKING SKILLS

Rubinstein's Patterns of Problem Solving, also known as Engineering II on UCLA campus, was first offered as a course at the university in 1969. It was conceived as a course that would serve to integrate skills and attitudes by improving the creative problem solving abilities of the learner. Emphasis on process, and not merely on information and results, is stressed at all times (Tuma, 1980:26-27). Although heavily math oriented it is offered in the humanites as well and gives students in this field an opportunity to be exposed to objective tools such as numerical models, while introducing the student in physical or life sciences to subjective notions such as values (Ibid:30).

In 1973 a Peer teaching programme has been introduced into UCLA to provide the individual attention which was needed in many areas. Peers who are knowledgeable about the concepts and problems in the book assist any Engineering II student with homework or general concepts (Tuma,1980:30-31). This makes for a very practical programme since no special training is required.

Schoenfeld describes a number of heuristics which can be applied at varius phases of problem solving. These phases are: Analysis, Design, Exploration, Implementation, and Verification. Each of these phases have their own set of heuristics which are discussed in Nickerson et.al. (1985:199). Schoenfeld (Lochhead, 1979:316) contends that although problems solving methods are idiosyncratic, there are a number of general principles involved in arriving at solutions. Pupils makes use of certain methods. A method becomes a strategy.

Some strategies the pupil remembers other he does not. Those that he does are mostly likely to be the strategies which have proven to be successful in problem solving. Schoenfeld is in favor of the 'Thinking Aloud' method of problem solving and he advocates that this is a way of comparing the problem solving activities of experts and novices and a way for the novice to learn from the expert problem solver (Ibid).

A Practicum in Thinking is a course developed by the University of Cincinatti and centres around group dynamics. Some students have to listen while others attempt to solve a problem. The problem solvers echo their thoughts aloud so that the listeners know exactly how they arrive at their conclusions. David Perkins (Chipman,1985:348) holds the opinion that this programme has not come up with any positive gains.

3.4.5 THE WHIMBEY-LOCHHEAD APPROACH

The Whimbey-Lochhead approach to teaching is based on the assumption that the learner possess the basic skills required for the various required to complete the tasks. Users of the Whimbey-Lochhead approach draw from Feuerstein's diagnostic test to detect which cognitive functions are deficient when it becomes evident that certain skills are lacking. Feuerstein's treatment is also used to develop skills which are lacking (Nickerson,1985: 207) before the Whimbey-Lochhead (W-L) approach is continued.

W-L aims at equipping the learner with problem solving tools which have been used by experts and have proved to be effective. The programme start with stock taking of existing skills and expertise by the Whimbey Analytical Skills Inventory (WASI) test (W-L,1986:3-10). The problems facing the learner in the WASI- test forces him to concentrate on the material which he is reading. If questions are not read carefully an incorrect conclusion will be drawn. The items requires rereading in practically every case. At the end of the test the learner will already be used to reading and rereading questions and isolating important aspects of the question. The isolated information could be represented on paper and can assume any form, viz. pictorial, figural, verbal, and/or numeric.

The problems which are discussed in the analysis of the tests is a deliberate effort to make the learner aware of the skills which may

be lacking. They learn it as specific skills which are concentrated upon separately to allow the learner to master and apply them individually. Much attention is given to the actual reading and analysis of the problem. The learner is urged to **read aloud** in an attempt to convince himself that he understands what he is reading. He is also urged to **echo his thoughts aloud** (W-L,1986:22-23) so that he can analyse these and see whether it makes sense to him. In the case of Pair-Problem Solving (W-L, 1986:30-38) the problem solver has an additional advantage in that the listener can reflect on his thoughts and question his line of action. Whether right or wrong, if questioned, the problem solver will have to reflect on his thoughts to make sure that his approach is feasible and in harmony with the nature of the problem. The listener urges the problem solver to speak up when there is silence, a demand for constant vocalization (W-L,1986:29). It clearly spells out the route taken and then each step in the route is explained. Enough practice in this field should lead the problem solver to automatically implement these methods when necessary. The Pair-Problem solving method enables the problem solver to constantly monitor his thought processes and if he fails or seem to fail to do so the listener is always there to remind him to echo his thoughts aloud so that he can reflect on what he is thinking.

Although the listener does not provide any clues or cues to the solution of the problem he plays a very important in keeping the

problem solver alert and concentrating on the problem he is busy solving. The listener questions information extracted form the problem simply to check whether the problem solver is sure that he has interpreted the question correctly and that he did not plunge in upon seeing specific numbers or a given general pattern of a problem. This often happens when the problem solver recognises a few isolated parts within a problem. He simply puts them together the way it is often done and disregards their relation within the specific case at hand. Integration is obviously lacking in problem solvers operating in such a manner.

One of the most important heuristics taught is breaking the problem down in smaller, more manageable parts to make the solution thereof easier. The problem appears less complicated if broken down into smaller problems. Since this is illustrated very clearly in the programme the learner sees the benefit thereof and tries to make it part of his problem solving skills.

Another heuristic basic to all problem solving which is taught in the W-L programme is to concentrate on what is being read. The solutions to specific problems discussed in the programme clearly indicate to the learner that it is necessary to read through the problem once to get an idea of what the problem is about and then to reread the problem in order to isolate important information. This heuristic, the isolation of important, relevant information, should be applied to all problem situations. The learner is urged

to echo his thoughts aloud when solving a problem. This is of great help since ideas become more meaningful in that way; listening to oneself while echoing your thoughts aloud will immediately invoke a feeling that "this is the real thing" or "what a stupid idea".

What makes the programme so much more successful is the provision of a checklist of errors in problem solving to give the learner an idea of what to look out for when scanning his mistakes. He can then concentrate on improving these when working through the given problems.

3.4.6 DE BONO'S CoRT PROGRAMME

Edward De Bono's Cognitive Research Trust (CoRT) Programme is probably the best known and most widely used programme for teaching thinking skills explicitly. This view is expressed by Jack Lochhead in the introduction to THINKING. The Exapnding Frontier (Maxwell,1983:xiv). This very practical course does not require special training of teachers although training would be an advantage since the teacher would have had the opportunity to develop the skill to use the programme independently (Ibid).

The most striking feature of CoRT is the change in self-image, always turn out to be positive(Ibid:116). Four levels of objectives are identified, viz.;

1. That there is an area in the curriculum where thinking

is treated directly in its own right.

2. That pupils should come to regard thinking as a skill that can be improved by attention, learning, and practice.

3. That pupils should come to regard themselves as thinkers

4. That pupils acquire a set of transferable thinking tools which they can carry to other situations. (Ibid: 117)

De Bono defines thinking as "the operating skill with which intelligence acts upon experience." (Ibid; De Bono,1980:33). CoRT deals with the perceptual area of thinking. Because it emphasises perception CoRT is sometimes referred to as the "spectacles method". The precise aim of the CoRT lessons is to seek to correct short- sightedness and tunnel vision in its figurative sense. It does not seek to change traditional values of individuals. The CoRT approach is to crystallize different aspects of Thinking into definite tools or objects of attention eg. the OPV = Other People's Viewpoints and PMI = Plus, Minus and Interesting points (De Bono,1980:132).

Nickerson et.al.(1985:214) describes De Bono's approach as drawing a distinciton between vertical and lateral thinking. Vertical thinking is logical, sequential, predictable, and conventional within a set framework. De Bono addresses the lateral (Maxwell,1983:127), implying that his design is parallel rather than hierarchical (vertical). Lateral thinking is not necessarily sequential and predictable, and tends to restructure the problem

space (Nickerson et.al. 1985:214). De Bono, however, has only one section of his thinking programme dealing with lateral thinking. The other sections deal with the ordinary routine processes of thinking without any special creative element (De Bono,1980:105).

McPeck (Maxwell,1983:165) has the following to say about De Bono's work:

> "... what one finds in Teaching Thinking ... are not methods for teaching thinking but rather suggestions to generate different or unique hypotheses: what psychologists would call 'divergent thinking' or 'generative thinking'... It is the type of thinking often associated with creativity."

3.4.7 THE IMPORTANCE OF HEURISTICS IN THIS INVESTIGATION

The interest in Heuristic Approaches started almost six years ago but clarity on the concept was lacking. The Heuristic Approaches discussed above were vague at first, but at the start of this investigation became crystal clear with the study of the Whimbey-Lochhead Approach. The result was that much of the earlier work could fall in place rapidly and speed up the programme. It was not difficult to devise heuristics to facilitate the understanding of the relevant work. This enabled the subjects to combat their impulsivity much more easily as the content could now be mastered with much less effort.

3.5 CONCLUSION

The Educational Theories and Principles discussed above are very interesting, yet cognitively loaded. It is not possible to master understanding of these by mere reading and trying to memorize the works, but simultaneous implementation and application is required to make it functional. It is in this way that meaning can be attributed to the various aspects of these Theories and Principles. It is, however, impossible to implement and apply these if no theoretical basis exits. Since most of the acquired knowledge was always put into practice (or at least tried) it was of great benefit as it made the flow of events of the programme of investigation practically flawless.

In Chapter Four I have described is some detail the steps I have followed during this investigation. The data the investigation yielded are displayed in tabular as well as graphic representations. I have tried, as far as possible, to make sense of the data by, eg. interpretations next to specific graphs and further explanation of the data in the paragraphs following. As far as the results would allow I have drawn some conclusions and documented these.

It is a great pity that the methods devised here are not easily aquired by teachers in general as it does require a sound theoretical background of the theories and principles involved. I shall address this problem in Chapter Five and again refer to it in Chapter Six.

C H A P T E R 4

T H E R E S E A R C H P R O J E C T

A SUMMARY OF THE WORK DONE DURING THIS PROJECT

4.1 ANALYSIS OF THE PROBLEM

As pointed out in Chapter 2 pupils have difficulties of various kinds when they try to solve problems. In BIOLOGY the inability to to cope with problems, particularly on the HIGHER GRADE, stems from the many cognitive operations which these pupils lack. Interviews conducted previously with seven subjects (The PIONEER GROUP) as part of previous course work and showed that all the subjects displayed alarming impulsive behaviour when attempting to solve a problem. Two other major deficiencies detected were:

a) spatial and temporal orientation and
b) the use of two sources of information simultaneously.

There were few other cognitive deficiencies but the above mentioned seemed to be more common among these pupils. The decision, then, was to address these in order to help the pupils in their problem solving activities. It is probably because of these deficiencies that the process of concept formation is greatly impaired. The lack of understanding of the relevant concepts makes it difficult for them to solve problems

since they do not have the basic knowledge or know-how to successfully solve the problems they are confronted with in examinations.

Another reason for choosing these cognitivie operations as a starting point in an attempt to correct these deficiencies is their occurrence at the input level. The hope was that more accurate input would somehow improve on or eliminate the deficiencies which occur at the elaborational and output levels. Gathering informaion is a futile task if it is not done meaningfully. One could hardly expect reasonable elaboration with 'chunks of unrelated information'. The latter is often the result of poor information gathering skills. The information thus gathered cannot be reconciled by the learner as s/he is unable to put the pieces together. Mention was made in Chapter 2 that the skills required by pupils to facilitate their problem solving do not develop automatically in most of our pupils. This programme is an attempt to inculcate in the pupils the skills required to enable them to cope with problem solving in Biology.

Having identified the deficient skills to concentrate on the problem now was to find a way to have the pupils acquiring these cognitive skills which they were lacking. A method with the least strain which would yield positive results in the quickest possible manner was sought. This led to do the cognitive instruction on two different levels. The skills were subtly

introduced via the normal, everyday teaching and problem solving tutorial sessions in two of the classes.

THE EXPERIMENTAL GROUP 1

From one of these classes a group of 12 (twelve) volunteers were subjected to a deliberate programme of Cognitive Instruction. This group had intensive training in the identification and application of the required cognitive skills. The purpose of this exercise is two-fold. First, to determine whether the acquisition of these skills would facilitate better concept formation in pupils. Second, to determine whether pupils benefit more from the subtle, integrated approach (integrated with the normal teaching of Biology) or from deliberate instruction, having to spend more time on the extra sessions and work.

EXPERIMENTAL GROUP 2

Since I was only teaching two matric classes during this investigation I used the remaining class as the experimental group 2. These pupils did not know much about the programme as the introduction of skills was a subtle, integrated process. This group of pupils was regarded by the school as lowest on the academic ladder. Most of them did not take Math and specialized in social sciences and practical subjects.

THE CONTROL GROUP

A third group of pupils formed part of the programme. They

were taught by another Biology teacher and remained uninformed about the finer details of the programme. Since I was not teaching this group there was no chance that my ideas would rub off onto them.

CRITERIA FOR SELECTING GROUPS

The criteria for selecting the groups stemmed from the position of the group on the academic ladder. I did not want to have as EXPERIMENTAL GROUP 1 a group of students who would, on the basis of their existing 'high level of intelligence' (as branded by the school) produce some 'false positive' result. Neither did I want to work on the other extreme, having the group which the school regards as 'lowest on the intelligence ladder' of all final year pupils, as the EXPERIMENTAL GROUP 1 and get 'false negative' results. I thus opted for the group with an 'intermediate level of intelligence' to represent the EXPERIMENTAL GROUP 1 and then could easily compare the results to the group above and below them.

Since the subjects of the EXPERIMENTAL GROUP 1 selected themselves there can be no arguments regarding favouritism or 'window dressing'. The selection of the groups has in all respects been objective. At the start of the investigation I had no idea of the potentials of the individual pupils except for the rating of the classes in which they were placed. Some pupils are in particular classes because of academic ability and others because of reasons which may have become evident whilst reading Chapter one.

4.2 THE RESEARCH PROGRAMME

This programme is discussed in seven steps for the sake of convenience only. The steps are discussed in brief except for step five which describes the programme of deliberate cognitive instruction to Experimental Group 1 (E-G 1).

STEP 1: INITIAL ASSESSMENT

An INITIAL QUESTIONNAIRE (refer Appendix 8.2) was given to ALL THREE GROUPS to complete. This served to determine the level of understanding and knowledge of certain concepts at the start of the investigation. The results of this 'test' is documented in section 4.3 below.

STEP 2: TEACHING BASIC PROBLEM SOLVING

Both E-G 1(EXPERIMENTAL GROUP 1) and E-G 2 (EXPERIMENTAL GROUP 2) had subsequently dealt with some problem solving activities in class during which they were taught to look for certain keywords, cues and relations before they attempt to answer any questions. They were also taught to analyze questions carefully, extracting THE QUESTION, and not answer what they think the question ought to be. The importance of reading with comprehension was emphasised to the extent that at each tutorial session at least one person would say : "We ARE reading SENTENCES and not words," or "Remember to look for 'EXECUTIVE'

"words like...". At this stage the pupils were beginning to get annoyed at the intervention.

Pupils were allowed to solve problems as a 'combined effort' where they were allowed to mix and discuss the problem solving strategies freely in the class. Ten to twelve of these sessions were held during the programme. This was incidental. At this stage the idea of a programme of investigation was put aside and nobody regarded the class tutorial sessions as something special.

STEP 3: THE INITIAL INTERVIEW
(Refer Appendix 8.3)

Few of the E-G 1 (EXPERIMENTAL GROUP 1) were briefed a little later and specific arrangements were made for them. During the time that the sessions were held in class some of the pupils of E-G 1 attended separate sessions after school both at school and at my house. These after school sessions were held very early during the programme. Not all of E-G 1 sat for for the initial interview. During this time deficiencies in their problem solving strategies were pointed out.

What this means is that the eight who sat for these interviews were aware of their problems a little longer than the rest of E-G 1. This should not be regarded as a problem as those who could not attend the interviews exerted every effort possible to get to know what had transpired. In the ensuing activities a concerted effort was made to bring them on par with the rest.

STEP 4: HANDOUT OF CHECKLIST

Pupils of the E-G 1 and CONTROL GROUP have received a handout which is an extract from 'Problem Solving and Comprehension' (Whimbey and Lochhead, 1986, 18 -20). I have no idea whether CONTROL GROUP has read this at any time but I have dealt with this handout during the E-G 1's Sessions. E-G 2 not receive the handout but much of the information on the sheet was conveyed to them during teaching sessions. Following this was the deliberate teaching and the direct instruction to the E-G 1.

STEP 5 : DELIBERATE COGNITIVE INSTRUCTION

The programme of deliberate cognitive instruction was started shortly after the interviews of E-G 1. The problem from the initial interview (refer Appendix 8.3) was used in conjuction with another to teach the cognitive skills. The reason for this is that the pupils were familiar with the work and could concentrate on acquiring the cognitive skills. While they were busy solving the problem I walked through the working group and pen symbols on the papers of some subjects where necessary. The letter "I" featured prominently and one of the 'old hands' (from the first interview) identified it as implying **IMPULSIVITY**.

A discussion on impulsivity followed during which they were allowed to document some strategies which they could employ to

avoid this impulsivity. Each subject then read his/her suggestions aloud and the others would add or modify their list during the reading session. Sometimes a discussion followed a contributor's comments if the other subjects felt that the point was not valid, was a repeat, or could be part of another point mentioned earlier, i.e. an elaboration on an earlier point.

The same was done for spatial and temporal orientation. In this case, however, I was the main contributor to the strategies as the pupils were floundering for answers to their problems. The pupils had schematically or diagrammatically represented the problem situation and then proceeded to organise their ideas from the conrete situation. To resolve the temporal aspect pupils were asked to draw a scale or time axis. This turned out to be a big disaster in most cases and eventually I had to spend half of one session just explaining a time axis and choosing a point of rotation or orientation. Once they had understood responses like "Oh, that's how you do it," and "Now I understand," were common. An indication that they were at ease with the skill was displayed by them applying it to other problem situation they had encountered previously.

In both the first and second sessions the pupils were made aware of the fact that they are making use of two sources of information and that more attention would be given to this aspect in the last session. The last session, then, was devoted

to concentrating on the use of two sources of information simultaneously. Most of the subjects could identify the two sources of information but the effective use of them was a problem for a number of reasons.

First, when reading they tend to ignore the second source (which in this case is a table of data) completely or would read through it as if it is 'just there' Only two candidates correlated the table to the paragraph while they were reading. The table contained sets of information, viz. the number of individuals at a given time. One subject actually read the given times and then proceeded to the line below and read all the numbers without relating the two sets of information. She then proceeded to answer the first question.

Second, while in the act of solving a specific problem many pupils would check the information in the paragraph only. Only when the question instructs them to draw a graph would they consult the table. One subject openly admitted that when she sees a table of information like the one on their sheet she expects a graph somewhere in the list of 'questions' and would look at the table when she enccounters to such a question.

Third, they fail to use certain phrases or descriptions in the paragraph and correlate it to specific sets of data. Fourth, they fail to 'read into' the tables of figures, i.e.

extracting implicit information which in their case was obvious as required by the type of question, yet most of them could not cope. It is during this last session that one of the subjects remarked: "All the time they tell you **what** to think. Now that you're almost out of school they want to tell you **how** to think." This feeling was shared by most of the subjects judging from the discussion on how they were hit by their teachers when they did not do things **exactly** the way she had told them to do it. They claim that they were not allowed to use their imagination at all. They were never allowed to improve on the methods of the teacher even if they had an easier or better way.

Many of the subjects felt that being allowed to express answers they way they wish to, as long as it is correct, should make the ask of the learner so much easier.

HEURISTICS APPLIED DURING THE PROGRAMME

In addition to the cognitive skills the pupils of the EG-1 and EG-2 were taught some HEURISTICS to further facilitate the process of concept formation and integration. The teaching of these Heuristics was done as part of the normal running of lesson in the class. The heuristics which were used have been devised about a year ago and it seemed to be effective in promoting concept formation. The most important concept taught via heuristics is 'HOMEOSTASIS', being the central concept of

the topic. A detailed description of the heuristic approach applied in this case follows. Breaking a term or concept into its functional components makes the understanding thereof much easier. Once the functional parts have been identified each can be dealt with separately. To understand the concept as a whole the parts are put together in context and the holistic view of the concept explained. It is important to review each part, put the part together and review the whole.

The heuristic can be summarised as follows:

1. breaking up the concept (if possible)
2. explain each part separatley
3. review each part
4. put the parts together to form a meaningful whole
5. review the whole concept

To explain the meaning of a part of a concept it is sometimes useful to trace the stem of the functional part. Most of the Biological terms are of either Latin or Greek origin. As the student progresses to through junior Biology he learns these basic Greek and Latin words. It is assumed the he would have some idea of these derivatives when he reaches matric. In cases where the stem is completely unknown the components are treated as separate entities for much longer.

The elucidation of the term "HOMEOSTASIS' has been approached in the manner described below. The pupils had to identify the functional components and attach meaning to each of the

components. Together we arrived at the functional components being HOME(O) and STA(SIS). They were asked to raise their hands in order to contribute to attributing some meaning to the word 'HOME'. The reason for this procedure is to eliminate a state of confusion of everyone talking together and nobody listening. Although responses such as; "Home , mother, drag," and "Nag, nag, nag," did emerge but the overall response can be summarised as follows:

HOME is where you live. It is the place where you always return to. No matter what causes you to leave home to go in whatever direction the return is always back to this point. In the body there is a certain condition or status that prevails. In order to function properly the body tries at all costs to prevent this condition from changing, i.e. stops anything from leaving home or if it does, tries to get it back 'home'. 'Homo' , the pupils recalled, means 'the same'. It was then explained that the body tries to keep its internal environment the same, bringing it back to its 'functional levels' should anything have disturbed the equilibrium.

The second functional component 'STA(SIS)' was also analysed by the pupils in the way described for 'HOME'. A summary of the responses follows. 'STA' (stay) means not to move or to go, i.e. to be stationary and not dynamic or kinetic. The system tends to stay put at a specific point, not wanting to budge from this point. Thus the system which tends to be inert, trying to

avoid being changed by any adverse force. The two functional parts were then put together. Home, 'a point to return to' and Sta(sis), 'a tendency to stay put'. Relating this to the internal environment of the body the concept was summarised by the class as follows: HOMEOSTASIS is the tendency of the body to keep its internal environment constant at a specific point and to bring it back to this point should any force succeed in driving it off this point.

The body will react in various ways if it is driven beyond it limits or anywhere below its tolerable minima. The following served as a practical example of the process to illustrate the concept. The simple habit of eating was used to illustrate the above. If one consumes too much food at any given time the body will react. Should the body realise that while the food is still in your stomach it cannot cope with the bulk of food it is going to expell the food, not only the excess but often all the food in the stomach, i.e. vomiting will occur. If the body only becomes aware of the excess of food when in the small intestine then hypercolonic movement may cause diarrhoea may occur to rid the body of the excess of food.

Essentially the body tries to get rid of this overload which it cannot cope with. Alternately, when the body feels a lack of food a centre in the brain is stimulated and it sends 'hunger' messages to the stomach which reacts in preparing itself for

receiving anticipated food. Should no food reach the stomach some funny noises would be heard as the juices of the stomach have nothing to work on. Eventually this will cause hunger pains and the person is forced to eat. If, due to regular practice, the body redefines the upper and lower limits for given substance, it would only react when these new limits are transgressed. It would initially try everything in its power to restore the old limits, but as the new setting becomes the overriding limits the body settles to these new limits. At this stage a different example of a problem of homeostasis was presented to the class to work on and see if they could apply the principle.

To facilitate the process of integration and understanding the concepts associated with this process another heuristic was used. This operates on the basis of relating the components to everyday phenomena. What makes it different of the one above is the fact that some of these concepts operate in antagonistic pairs and the hormones associated with the processes have antagonistic effects on the body.

The subject of nutrition had been dealt with at this stage and I could draw on information from this area to integrate with hormonal functioning and excretion. The terms 'HYPERGLYCAEMIA' and 'HYPOGLYCAEMIA' is of special interest since it is central to the integration of all process in the body. Each term was

analysed as described in the earlier heuristic. 'Hyper' was correlated to the HYPER- market which indicated something 'larger-' or 'bigger than' the normal. A similar correlation for 'Hypo' could not be found. Since the pupils were acquainted with the term 'hyper' the latter was used as a starting point. The procedure was as follows: The term 'hypo' is the opposite of 'hyper'. Thus it was stated that 'hypo' means 'less -' or 'lower than' the normal. The association built in here is phonetic, viz. HYPO rhyming with BELOW (the normal).

Whether the following can be regarded as a heuristic is not certain. The following was greatly emphasized greatly in the sessions of both the E-G 1 and E-G 2. The strategy was a verbal instruction throughout the course of the tutorial sessions and can be summarised as follows:

'STAY CALM, WHATEVER HAPPENS AROUND YOU. DO NOT HAVE YOUR TREND OF THOUGHT BE DISTURBED BY ANYONE ENTERING, TALKING, FIDDLING, OR PACING UP AND DOWN IN THE CLASS !! DO **NOT** BE INTIMIDATED.' Some exceptions to the above strategy were listed. These pertained particularly during an examination when announcements are made. These heuristics seemed to be useful throughout the teaching and it appeared at that time (judging by the enthusiastic response of the pupils) that they had enjoyed learning the topic and that they 'understand' the work.

LOOPING, FEEDBACK, INTEGRATION

The phenomenon of 'NEGATIVE FEEDBACK' signifies THE controlling mechanisms of processes in the body. A given reaction would be stopped when the body has managed to get its levels back to normal by the reaction which was elicited previously when an imbalance prevailed in the body. It was not very difficult to clarify this concept as most of the pupils had an idea of what it means to get some feedback and that negative would mean 'no more, cancel or stop what is happening in this area'. The understanding of this phenomenon was accomplished by drawing on the existing knowledge of the pupil and setting scenarios for them to identify such a controlling mechanism.

For the purpose of this programme the term was laid open to the class. Examples of phenomena occurring in everyday life outside the body were provided by pupils. The pupils then had to identify such a phenomenon in their own bodies. Drawing from many aspects of human physiology which the pupil had already covered negative feedback was a discovery on the part of the pupil rather than information supplied by the teacher, who did virtually nothing but drop the term. Not much deliberation or consolidation could be done as time was limited. This made the Final Test so much more interesting as it was up to the pupils to integrate the work which they had learnt. Not one of the E-G 1 or E-G 2 had any time for practising problems

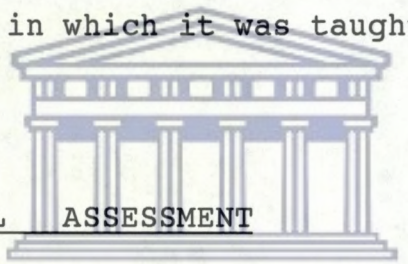
relating to integration across the syllabus as I tried to complete as much of the syllabus content before handing the pupils over to another teacher. I had no idea what the Control Group had been practising but they were ahead of both the other groups in covering content.

STEP 6: THE FINAL INTERVIEW

After this session of cognitive instruction interviews (refer Appendix 8.4) sessions were arranged with ALL OF THE E-G 1, FEW of E-G 2 and as many as possible of CONTROL GROUP. The reason for this is the fear that E-G 2 would be over-exposed to the deliberate instruction. Since CONTROL GROUP (C) knew nothing or very little about cognitive instruction this interview probably would not have any significant effect on the performance of these subjects. During the interviews of C, however, it became apparent that few of the subjects who are very friendly with my E-G 1 had picked up some strategies like underlining of important information and the careful "reading with comprehension" pattern. Two of the subjects of C were proud to announce that they are friends of my 'best Experimental Subject'.

These interviews were aimed at determining which cognitive skills were present at this stage (+- eight months after the INITIAL QUESTIONNAIRE) in the EG-1, a representative sample of

C and few of EG-2. Again only a few of E-G 2 sat for the reason mentioned earlier. The interview at this stage dealt directly with HOMEOSTASIS since all the groups had by now completed this topic and should be able to integrate all concepts learnt in the different aspects of homeostasis if they truly understand these concepts. [In the past many pupils could define each concept 'by the book', and relate it to a specific aspect of homeostasis but most of them failed to integrate the concepts and present a holistic view of homeostasis. They would treat the concepts and related information in a piecemeal fashion, maybe the way in which it was taught.]



STEP 7 : FINAL ASSESSMENT

All groups sat for the FINAL TEST (refer Appendix 8.5) at more or less the same time of the day. The test required integration of a number of concepts from various of human physiology which appear as separate units in the text books. It is also taught in this way for systematic reasons. Most often it remain as separate units for most pupils. At the time of this test this was the picture in the minds of the experimental subjects. Any integration which the subjects display is an effort of their own. The best response from each group is displayed as Appendices 8.9 A, B, and C.

A REPORT of the findings of the INITIAL and FINAL tests is represented in code form below. The items were chosen to guage how much the subjects knew about certain aspects of homeostasis at the onset of this programme. The FINAL TEST was designed to determine how well the concepts were mastered and could be used in conjunction with one another.

The coded form will be followed by a representation of the data in the form of graphs. Some of the data is represented as qualitative statements instead of graphs. Some excerpts from the interviews are supplied as an appendix (8.1) to this paper.

4.3 PRESENTATION OF RESEARCH DATA

KEY : n = no answer p = poor r = reasonable
g = good y = yes / spot on

SUMMARY OF INITIAL TEST RESPONSES

[Refer Appendix 8.2 for test]

EXPERIMENTAL GROUP 1

ITEM NUMBER

1	2	3	4	5	6	7	8	9	10	11
3p	4p	11p	5p	4p	4n	4n	3p	3p	7n	3p
3r	4r	9r	14r	18r	4p	5p	13r	16r	10r	11r
1g	2g	3g	4g	1g	13r	10r	7g	4g	5g	9g
16y	13y				2g	4g			1y	

THE RESPONSES TO ITEMS 10 & 11 EXPRESSED AS A PERCENTAGE OF THE NUMBER OF SUBJECTS IN THE GROUP

ITEM 10	NUMBER 11
30% n	13% p
43% r	48% r
22% g	39% g
5% y	0%y

Items 10 and 11 have a direct bearing on Homeostasis and reflects, to some extent, the knowledge on the previous questions.

EXPERIMENTAL GROUP 2

ITEM NUMBER

1	2	3	4	5	6	7	8	9	10	11
	1n	1n	1n		7n	1n	1n	2n	20n	3n
	1p	8p	11p	20p	7p	9p	5p	4p		7p
14r	6r	14r	11r	8r	13r	18r	15r	18r	6r	14r
			4g		1g		6g	4g	2g	3g
14y	20y	5y	1y				1y			1y

THE RESPONSES TO ITEMS 10 & 11 EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF SUBJECTS IN THE GROUP

ITEM NUMBER 10	11
72% n	11% n
	25% p
21% r	50% r
7% g	11% g
	3% y

CONTROL GROUP

ITEM NUMBER 1	2	3	4	5	6	7	8	9	10	11
1n		1n		5n	8n	7n				1n
1p	1p	11p	1p	7p	7p	14p	7p	7p		4p
	3r	9r	5r	8r	6r	1r	5r	8r	5r	4r
	1g	3g	17g	4g	3g	2g	7g	9g	13g	7g
22y	19y						5y		6y	8y

THE RESPONSES TO ITEMS 10 & 11 EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF SUBJECTS IN THE GROUP

ITEM NUMBER 10	11
21r	4n
54g	17p
25y	17r
	29g
	33y

SUMMARY OF FINAL TEST RESPONSES

[Refer Appendix 8.5 for test]

KEY: DEFIN = definition

ABS = absorption

FEEDB = feedback

INTEGR = integration

HYPO/HYPER are prefixes

ITEMS 10 & 11 = ITEMS 4d & 4b respectively on test paper. I have used 10 & 11 as a means of comparison with items 10 & 11 above.

THE NUMBER OF RESPONSES EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF SUBJECTS IN THE GROUP

EXPERIMENTAL GROUP 1

ITEM NUMBER 10	11	DEFIN	ABS/ REABS	HYPO/ HYPER	FEED BACK	INTE-GRAT.
73 n			37 n	46 n	46 n	18 p
	27 r	18 r	18 r	18 r	9 r	18 r
	27 g	64 g	18 g		18 g	55 g
27 y	46 y	18 y	27 y	36 y	27 y	9 y

EXPERIMENTAL GROUP 2

ITEM NUMBER 10	11	DEFIN	ABS/ REABS	HYPO/ HYPER	FEED BACK	INTE-GRAT.
5 n			14 n	29 n	14 n	
24 p	14 p	10 p	24 p		10 p	19 p
48 r	19 r	19 r	38 r	19 r	29 r	29 r
19 g	57 g	66 g	14 g	24 g	19 g	38 g
5 y	10 y	5 y	10 y	29 y	29 y	14 y

CONTROL GROUP

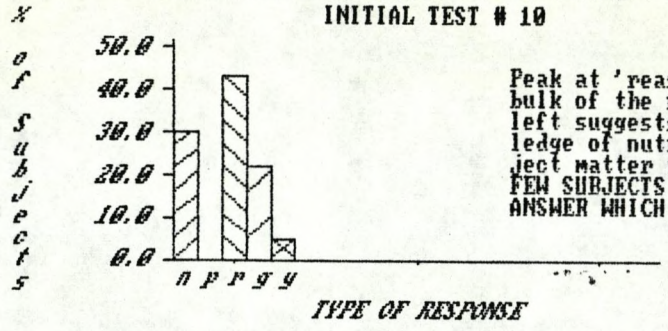
ITEM 10	NUMBER 11	DEFIN	ABS/ REABS	HYPO/ HYPER	FEED BACK	INTE- GRAT.
40 n	7 n	13 n	7 n	100 n	100 n	80 n
27 p	33 p	7 p	40 p			20 p
13 r	40 r	27 r	53 r			
20 g	13 g	40 g				
	7 y	13 y				

The graphs below are representations of the above data to facilitate easier interpretation of the results. Due to the limitations of the graphics program the "Y"-axis is labelled in short only. The correct label of the "Y" axis is as follows: The number of responses as a percentage of the total in the group.

The analysis of each graph is inserted next to the graph concerned to facilitate easy reading and understanding of the results Item number 10 is a nutrition related question and most of the questions preceding this item is related to it. Item 11 is related to nutrition as well as the endocrine and excretory systems. Some of the questions preceding it are an integral part of this question. It is for this reason that the emphasis was on these last two items to summarise the initial level of understanding of the topics and the level of integration. Since at this stage **no integration was evident in** the works of any of the subjects INTEGRATION is not listed as an item here.

INITIAL TEST ITEM 10

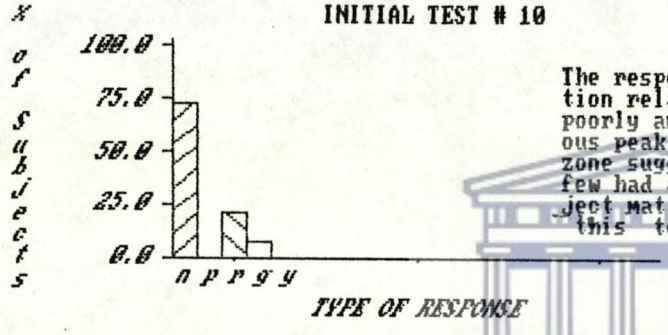
EXPERIMENTAL GROUP 1



ANALYSIS COLUMN

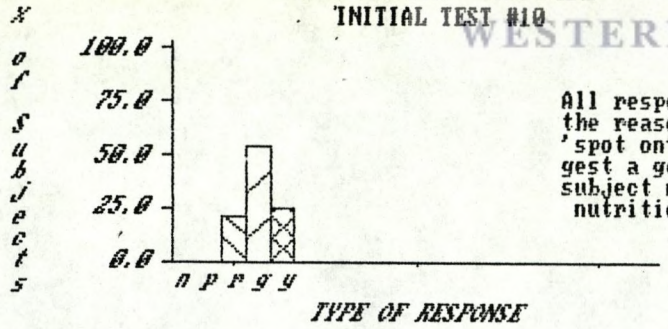
Peak at 'reasonable' with the bulk of the remainder to the left suggests that the know ledge of nutrition related sub-ject matter is limited.
FEW SUBJECTS MANAGED TO GET AN ANSWER WHICH WAS 'SPOT ON'

EXPERIMENTAL GROUP 2



The response to this nutri tion related question is poorly answered. An enorm-ous peak in the 'no answer' zone suggesting that very few had an idea of the sb-ject matter relating to this topic.

CONTROL GROUP

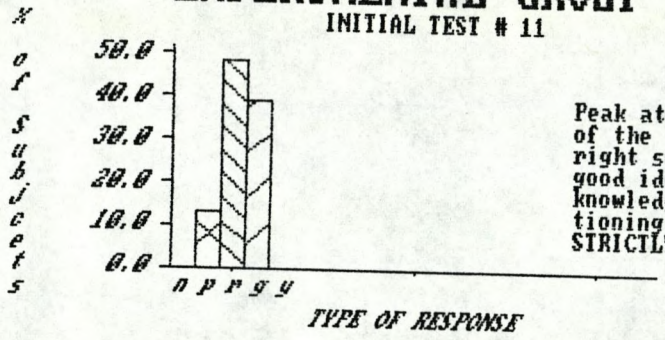


All responses are within the reasonable to 'yes' or 'spot on' range. This sug-gest a good command of the subject matter relating to nutrition.

INITIAL TEST ITEM 11

EXPERIMENTAL GROUP 1

INITIAL TEST # 11

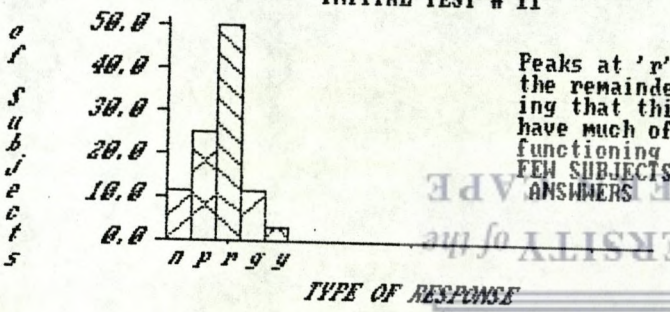


ANALYSIS COLUMN

Peak at 'r' with the bulk of the remainder to the right suggesting a fairly good idea of the general knowledge on gland functioning and excretion. NO STRICTLY CORRECT ANSWER !

EXPERIMENTAL GROUP 2

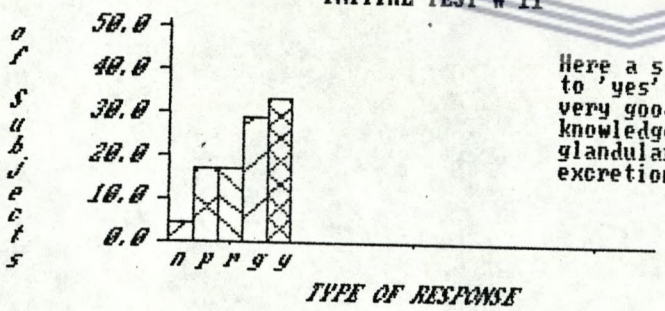
INITIAL TEST # 11



Peaks at 'r' with the bulk of the remainder to left suggesting that this group does NOT have much of an idea of gland functioning and excretion. FEW SUBJECTS HAD 'SPOT ON' ANSWERS

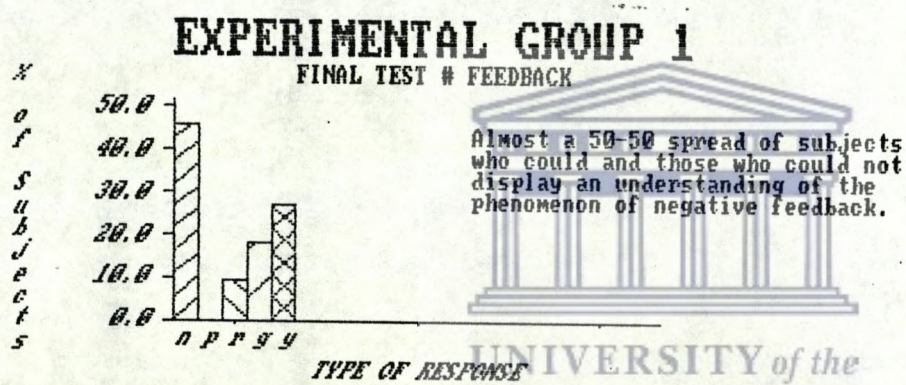
CONTROL GROUP

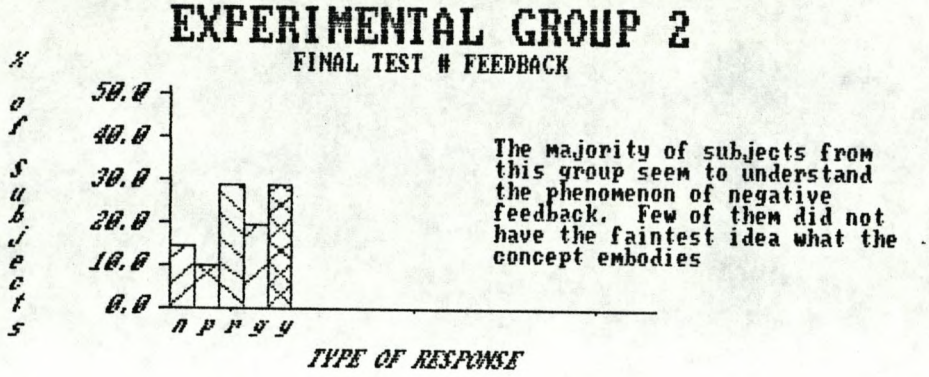
INITIAL TEST # 11



Here a steady upward trend to 'yes' which suggests a very good command of the knowledge related to glandular functioning and excretion.

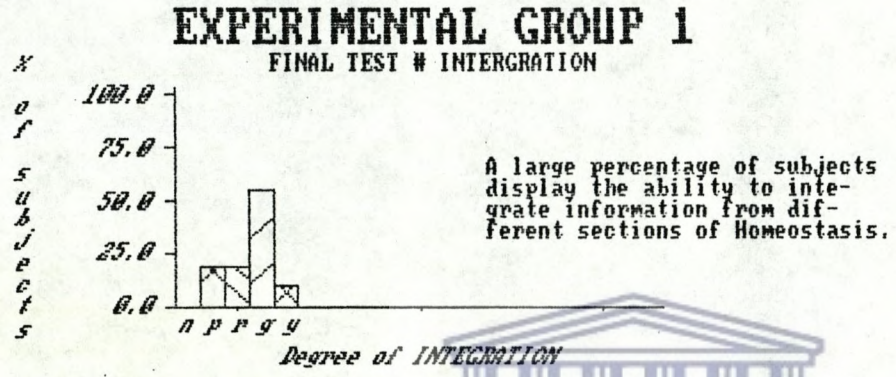
Since the FINAL 'TEST' comprises of so many components. Only the last two items, which is the essence of the 'test', will be represented graphically. The analysis will be written next to the graphic representation to make interpretation easier. An attempt to compare the results of the INITIAL and FINAL 'TESTS' will follow and possible conclusion conclusions will be drawn. This is MY interpretation of what I see represented by the graphs.

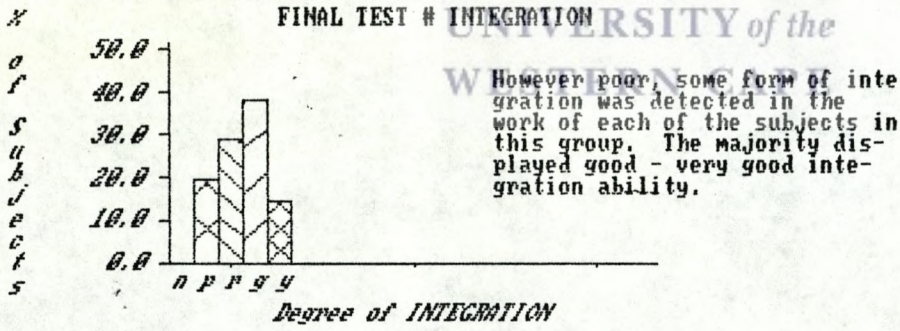




CONTROL GROUP FINAL TEST # FEEDBACK

SINCE ONE OF THE SUBJECTS IN THIS GROUP COULD PROVIDE AN EXPLANATION OR EXAMPLE OF NEGATIVE FEEDBACK I DID NOT PLOT A GRAPH. RESULT: 100% n





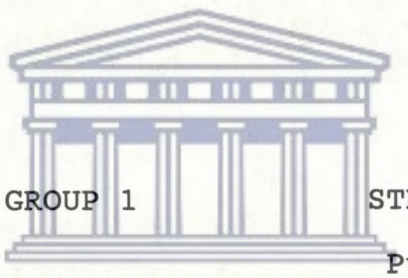
CONTROL GROUP FINAL TEST # INTEGRATION

80% OF THE SUBJECTS SHOWED NO SIGN OF INTEGRATION

20% OF THEM DISPLAYED REASONABLE INTEGRATION.

For the same reason provided above I did not plot a graph here.

At some time early during the program the Whimbey Analytical Skills Inventory (WASI) was administered to the E-G 1 and the CONTROL GROUP. The results of this test is listed below. The WASI test was not administered to E-G 2. The discussion of this test may have led to direct Cognitive Instruction to this group. This group could also have developed a complex as their performance in this test may have had a negative influence on the self-image of most of them. With the CONTROL GROUP it did not matter whether they had done the test or not. This group had no discussion following the test as our encounters were limited. The Scores which were obtained for the WASI-test are tabulated below.



WASI TEST SCORES

STD 10C	EXPERIMENTAL GROUP 1	STD 10B	CONTROL GROUP
Pupil 1	8	Pupil 1	15
" 2	10	" 2	16
" 3	13	" 3	20
" 4	14	" 4	20
" 5	14	" 5	23
" 6	17	" 6	23
" 7	17	" 7	23
" 8	18	" 8	24
" 9	18	" 9	24
" 10	19	" 10	24
" 11	20	" 11	24
" 12	20	" 12	26
" 13	21	" 13	27
" 14	22	" 14	27
" 15	23	" 15	27
" 16	23	" 16	28
" 17	24		
" 18	24		
" 19	25		
" 20	25		
" 21	26		
" 22	34		
TOTAL	435		371
AVERAGE	19.77		23.19

4.4 ANALYSIS OF THE RESEARCH DATA

4.4.1 REPORTING ON THE ABOVE DATA

THE INITIAL TEST

Rating the three groups in order of merit on the basis of the scores in the INITIAL TEST the CONTROL GROUP appears at the top of the list. E-G 1 follows and then E-G 2. The findings here coincide with the school's rating of the classes academically by achievement in Math and Science. As stated earlier the majority of the subjects in the E-G 2 do not take Math.

THE FINAL TEST

However enthusiastic the subjects of the E-G 1 were during the whole of the programme they seemed awfully tired and frustrated at the time that they had to take the FINAL TEST. This became evident from the comments by the subjects in this group. Although most of them did fairly well during the interviews they displayed very little lustre at this stage and did not fare very well at integrating the concepts. Two of the subjects who were lagging very much during the Deliberate Cognitive Instruction sessions did much better than the others in this FINAL TEST. It seems that they had not reached the level of saturation that the other subjects seems to have experienced at the time of the test. One of the E-G 1 subjects was simply just a very slow person who hardly does anything for herself. She displayed a

strong will to change her situation but her inertia seemed to be too great to overcome in such a short period of time. For this reason she had been lagging during most of the course of instruction.

The rating of groups in the Final Test was done on the basis of the degree of integration. This was determined by the way subjects defined or described the terms and to the extent to which they linked the various terms in meaningful ways. E-G 2 has displayed the highest degree of integration, individually as well as the group as a whole. E-G 1 follows and the poorest responses came from the Control Group.

Although the subjects of the CONTROL GROUP had the factual knowledge to define some concepts they are incapable of integrating the concepts. These subjects did not learn the cognitive skills required to allow them to integrate the various concepts. These cognitive skills facilitates the integration which leads to a holistic picture of the phenomenon of homeostasis. This would enable the recognition of feedback mechanisms which are in operation to maintain physiological homeostasis. Subjects of the other groups were introduced to these skills. It is during the application and exercise of the skills during problem solving sessions that the role and meaning of feedback mechanisms is realised, although not explicitly mentioned.

On page two of Chapter One I have mentioned a concurrent programme. The subjects of this programme are unaware of what they have been subject to as they have come to know my teaching they way it is being described throughout this investigation programme. Very importantly, as a measure of control, these were subject to this Final Test prematurely. This group of pupils have been taught by me for more that two years and has acquired the cognitive skills as an integrated experience. In May this year I have subjected them to this test. At this stage they had just about covered nutrition as a topic. I confronted them with the words 'feedback' and 'negative feedback'. One of the pupils actually drew an example from the work covered in January- February this year, viz. Population Dynamics. The example quoted was environmental resistance to achieve Ecological Homeostasis. This was a new idea to me. Although the information was known I have never explicitly expressed environmental resistance as a negative feedback mechanism. I have not explained the term to these pupils. They have derived the meaning by their own deliberation. Within a space of about five minutes this aspect was addressed and the next day they wrote the test. These pupils displayed remarkable integratory ability and although not all the content was covered more than fifty percent of the subjects addressed the aspect on negative feedback. What is more important to me though, is their remarkable response in class without any help from me whatsoever.

During our next meeting I have asked the pupils what their impressions/feelings were about the test. They had to document these on paper and hand it to me. One of the subjects blatantly stated that they had not covered all the content. All of them mentioned the surprise. [They were not informed about the test beforehand.] Unfortunately some pupils blamed themselves, feeling that they should at all times be ready for a test and even read ahead of the work we had done in class. I did put their minds at ease and said that, as many of the pupils documented, it is a test for them to see how well they listen in class and how well they can handle surprise situations which require thinking.

4.4.2 WHAT CAN BE DEDUCED FROM THE ABOVE DATA

It is evident that **pupils need to be taught some skills** which will allow them to integrate subject matter, particularly when it is drawn from different topics of a study subject. The CONTROL GROUP has managed to obtain the highest scores on both the INITIAL TEST and on the WASI TEST, indicating that they have good memory ability as the work tested by the Initial test they had learnt in the previous academic year and yet they remembered most of it. I am positive that the Control Group would have been able to put the relevant sections of the work together had they been taught some cognitive skills. They definitely had the factual data to make such an integration possible.

The WASI test requires much Math, good general knowledge, and some vocabulary. Having the memory ability and general knowledge is not enough since WASI forces the subject to see the items in relation to others. There are always distractors and unless the subject can work out the relations between the given items s/he would not be able to answer the question correctly. It is in this area of integration that many subjects defaulted. They may have been able to work out one part of the answer but the other half would be lacking. Somehow they failed to see the relation between the items in the questions. Confronted with these items in isolation they may have been able to solve the problems individually, but when linked together, having one part of the problem dependent on the other, they failed to cope with the problems of this nature. This supports the assumptions that the pupils of the Control Group would have been able to integrate the information if they had learnt some cognitive skills.

In the sessions following more and more of the pupils of E-G 2 were interested in using listening to the methods of problem solving which was described. Initially some of them brushed off the idea of organizing your approach and said that 'they know how to answer questions'. Subsequent discussions, since most of these were open tutorial sessions, drew their attention. Pupils who requested information were given the relevant answers. Only that which they asked were answered, although some times

suggestions were made. These the pupils would try out and brag if they had managed to arrive at some conclusion before any of their friends. The idea of teaching thinking as a separate skill was very well received by the pupils, but most of them felt that it was done too late in their school career.

The subjects of E-G 2 started applying the 'ideas' more spontaneously. How long they are going to be able do so is not certain at this stage. The E-G 1 may be able to cope better at a later stage when they are not under the pressure of this 'new thing'. This statement is made on the basis of feedback from the PIONEER GROUP interviewed in 1989. A discussion of this follows later in this chapter.

4.5 COMMENTS BY SUBJECTS IN THE FINAL TEST

EXPERIMENTAL GROUP 1

With the exception of two subjects everyone had negative feelings about the test in some way or another, either feeling too stressed by the fact that they have to apply specific skills and document these or were sick of reading and being tested. To them it seemed an endless series of tests. Some of them commented about the vast amount of homework they still had to do. Since their training centred around activities of thinking I think by this time they have just had enough of thinking. One of the subject wrote that she does not feel like thinking about

her thinking anymore and that she just wants the test to be over and done with as soon as possible.

EXPERIMENTAL GROUP 2

Almost everyone in this group solved the final test as if it was just another test. Some of them had participated in the 'post-instruction' interviews and two of those who had sat for the interview did not complete the work sheet. One commented that she did not feel up to taking another test and the other that he did not feel like thinking. On the whole this group seems to have worked through the test without negative thoughts and just completed it because it was for me. This group is branded as the 'suds' of the matriculants and are the 'academic outcasts'. The bulk of them take practical subjects which has a very low esteem at our school.

CONTROL GROUP

Many of these subjects were enthusiastic about the participation in the programme. Some of them just did what they were told to do during the various activities but their participation was sincere. Few of these subjects participated with some negative attitude. Many of these subjects who sat for the post-instruction' interviews performed well. Some enjoyed it, some found it funny, and other said "yach, another test!". In the final test, however, I found that two subjects who had been very enthusiastic had actually also become tired of the 'tests' they

were subject to and wrote some negative remarks on the answer sheet. All the subjects, however, completed the work with whatever resources they had at the time and many put in much more effort to 'test' their readiness for the coming examinations. There were a few subjects who messed up and these were listed as 'spoilt papers'. As I know these subjects they are the type who would back out if they cannot handle a situation. If they could they would be the first to show it and boast about their ability.

4.6 CONDITIONS UNDER WHICH THE PROGRAMME WAS RUN

4.6.1 THE PROBLEMS

The 'set-up' at our school is hardly condusive to such a programme of investigation. Pupils often move from class to class; teachers always do. This makes preparation difficult and limits the time in which an activity can be meaningfully completed. The rush of completing the 'normal curricular acitivities', which does not leave space for innovation by teacher or pupils, is always felt by pupils at matric level as they are worried about 'the stuff that will appear in the examination papers'.

The introduction of cognitive instruction at this stage is thus slow as some of the pupils regard it as a 'waste of time'. For

those interested it takes about a week or two before they get used to the idea of learning 'something different'. Most of the subjects only became known to me at the start of the school year. Much time was spent initially to get to know the pupils. They had been taught by other teachers previously who do not teach matriculants yet. From both sides accomodations had to be made and since the classes are large (largest this year was 35 pupils in a class) it took a while. Coming to grips with the various personalities, sensitivities, and academic ability was another stumbling block. Many of these pupils have serious social and socio-cultural problems which I was not aware of.

Biology is a compulsory subject at our school and many pupils rebel against it. Complaints to the office did not help and pupils now have the attitude that they will just "show the principal that they will just fail". Pupils in this category retard class progress and often does not participate in the instruction programme. Leaving them to their devices while attending to other pupils actually works. They would pester other pupils to get a 'sneak preview' of what the participants are 'achieving' to make sure that they are not going to waste time their trying this 'new method'. Some of the 'rebels' eventually enjoyed the problem solving activities so much that they wanted every lesson 'to be like that'.

I have experienced problems directly opposing those mentioned above. Few pupils felt overconfident and did not see the need

to learn anything more to make them better learners or problem solvers. Even explaining how it will be used in the attainment of basic concepts and how it may be applied elsewhere did not make a difference to their choice of non-participation. Others were simply too lazy to still 'train to think'. This is how the volunteer EXPERIMENTAL GROUP 1 of 12 has 'selected' themselves out of a class of 28.

Audio-taping the interviews was virtually impossible at school because of the constant movement and noise from pupil doing physical training outside the classrooms. There is no 'quiet place' in the school for any type of interview. Those conducted at my home worked out best, but all pupils could not come at the times which I have stipulated. Since pupils were asked to write down everything that entered their minds and were prompted if they appeared to be thinking but not writing a good record of their train of thought was obtained. I have also written down some comments on their behaviour, what they had said, and their activities in general during the session.

Because pupils do not have a safe place to store their books at school they have to drag a pile of books with them every day. Most of them do not and an attempt to use different sources of texts simultaneously often ended in a scramble to a desk which could supply the deficient source. Very soon a system was developed in class where pairs would organise to bring the

complementary sources so that the load per person was reduced and sharing of books became an organised activity when required. However, some books were reported stolen as a result of laziness to carry.

4.6.2 THE MORE POSITIVE ASPECT

The experimental subjects were all highly cooperative. They were delightful, challenging, and enjoyed most of the 'brain-storming' activities. Some of the parents played their role in trans-porting their children to and from my home for the initial interviews. This was a good opportunity to audio-tape some interviews without any disturbance or background noise.

There was no opposition from the school principal to conduct this investigation at our school. Some of the teachers assisted me in the form of 'releasing' a pupil during a non-examination subject period to attend an interview or discussion. One of my colleagues actually supervised two of the tests.

Getting hold of materials to serve as a form of assessment was not difficult at all. Most of the materials were devised as the lessons progressed. Because the materials are all strictly related to the prescribed Biology syllabus it was not difficult to duplicate it at school as it served as an instructional

medium for the pupils. As indicated earlier most of the cognitive instruction was integrated with the normal class room activities.

Many of the pupils were serious enough about their academic performance and saw in this investigation an opportunity to discover themselves. Some of them were eager to know **why** they were performing at the levels they did, **what** they lacked and also what **they could do** to improve their performance. I have met some of the parents on a 'parent night' and some of them did enquire about the 'programme'. Some parents assured me of their support if their children has to stay later or has to come to my house again.

4.7 BRAINTREE HIGH SCHOOL - AN AFTERTHOUGHT

4.7.1 THE SET-UP

Through David Perkins and Bill Kendall I have met Pamela Storms, a Biology Teacher at Braintree. Pam is an excellent teacher with a very warm and beautiful personality. I am grateful to her for making the interviews, not only with her class but also with some Chemistry pupils possible. Braintree High School is a school of great esteem in Massachusetts.

I have interviewed 5 (five) pupils from the Advance Placement Biology class and 4 (four) from the Advance Placement Chemistry class. The latter has taken Accelerated Biology (which covers the same subject matter) earlier. The nine interviews were done over a period of two days. The interviewed subjects swore secrecy and I had no reason to doubt them. From the flow of events during the interviews it was evident that they had not been briefed by their peers. The interviews last 30 minutes each the same time I had spent with interviewees in the research at Belgravia High School. As is the case with most of interviews a short discussion was held with the subjects after the interview.

4.7.2 ANALYSIS OF THE INTERVIEWS

The aim of interviewing America School pupils was to determine whether the final year high school students (at least some of them) display the same cognitive deficiencies as those detected back home. The deficiencies are discussed separately below.

1. IMPULSIVITY

Eight of the nine subjects interviewed displayed impulsivity to some extent. Two subjects were very haphazard about the way in which they answered the questions and admitted that they do it all the time as they know that they will be able to get back to unfinished points later. One of these subjects had all the

answers wrong as he did not take the time to identify the given data properly beforehand. This oversight, he maintains, wouldn't cost him much as his answers would be marked on the basis of his initial wrong assumption. This does not hold all the time and he agreed that it is a very bad way of trying to solve problems. He is aware of the fact that he would not be able to go through a tertiary institution with those 'skills'. One of the subjects, on the other hand, displayed such organisation and systematics which surprised me. I have accompanied her before the interview. She did not appear to be the type who would show so much insight and mental agility. (My prejudice to pupils taking History as a major!). Some of the subjects started 'answering the questions' withouth even looking at the data, but soon realised that there was some reading to be done.

2. USING MORE THAN ONE SOURCE OF INFORMATION SIMULTANEOUSLY

Three subjects displayed the ability to use more than one source of information to solve a problem. This included the general and subject specific knowledge on the topic in question. Whether they had arrived at a perfect solution is not important. Of importance is the fact that they had drawn information from various spheres at every question they answered. Three others, at a very late stage, discovered that it would be quite useful to consult the given information to help them solve the problems. At this stage they had proceeded to either question

3 or 4 already. Two of the subjects hardly used the information and tried to solve the problem via generalisations drawn from the subject specific knowledge on the topic. They totally disregarded the fact that they had a given situation which they were confronted with and simply answered 'in the air'. Eventually when they decided to reread the information the interview time had elapsed.

3. SPATIAL AND TEMPORAL ORIENTATION

The spatial orientation of these subjects leaves much to be desired. One of the subjects displayed remarkable memory ability, successfully drawing on knowledge of Biology which he had acquired a few years ago. Yet he failed to see what was in front of him. The sketch whic accompanied a paragraph had clear points marked A, B, and C. He claimed that he did not know "where A and B was". Although he saw it there he did not know whether it was inside, outside or just in the vicinity of the cell and deduced that these points were there simply as distractors. C, which was situated **inside** a cell, he maintained refers to the blood vessel and its surroundings. This amazed me as I did not expect this from a person with so much 'memory'. B, the point clearly **between** the cell and the blood vessel, he said does not refer to either the cell or the blood vessel. This stunning assertion led me to probe further into his idea of spatial orientation. A, he said, lies outside everything so nothing would be happening there. This could be accepted if you

do not know anything about Chemistry, Physics, or Biology. It took a while before he realised that B is the **inbetweener** and that C is the **insider**. Most of the other subjects had the same problem and some of them never attempted the question as they could not orientate themselves at all.

Some of the subjects saw 'things that were not there' and complicated their problem solving. Creating all sorts of barriers for themselves instead of trying to make their lives easier did not surprise me at all. This is a common phenomenon when a problem appears to be too easy (cf. the Nine Dot Problem).

While working on some of the questions, prior to confronting the subjects with it, I made sure that all the facets required was built into the problem. Not one of the subjects managed to solve the problem of time and space. The timing of blood flow and where a specific mass of blood would be at a given time was an important factor in the diffusion/osmosis part of the problem. All subjects failed to apply their knowledge here.

Although one of the subjects could successfully recall the experiment and set-up in the text book he could not apply it to the sketch nor to his own body when in led the discussion in that direction.

4.7.2 REPORTING ON THE ABOVE AND SPECIAL COMMENTS BY SUBJECTS

The exercise supports the choice of cognitive skills made to teach to pupils. Although the three of the subjects displayed amazing memories in remembering a vast amount of fact learnt some time ago not one of them appeared to have all the cognitive skills concentrated on above. Most of the subjects lacks at least one of the skills. An exception to this is the History major who has proven herself guilty of only mild spatial disorientation but complete temporal disorientation. The reason for the success in problems solving I would ascribe to her frequent reading of articles, magazines and books on both History and Biology. Because she reads very much on her own she is forced to correlate the many sketches or photographs in Biological text to the written works. She therefore has much practice at using various sources of information simultaneously which fosters a systematic approach to her work. This would clarify her systematic exploratory behaviour during the interview as opposed to the impulsive behavior displayed by all the other subjects.

The very impulsive subject impulsively asserted: "I always do it like this" (impulsively) and aroused the impression that he was happy with it. He maintains that he always achieves good grades and that all the tests are the same so he know what to expect. He wanted to know whether he was supposed to learn

anything from the interview. I explained that I was only interested to determine which skills were present and which lacking. In the general discussion which followed he admitted that he does not think he would get through university they way he is operating right now. He admits to having learnt some organisational skills but does not know if and when he would apply them. He wants to to Medicine next year and specialize in Genetic Engineering. Some other subjects shared his sentiments of tests being all alike and that they probably would only need this type of skill later in their studies. It was difficult to fathom whether they were glad to know about these skills or sorry to know that they were lacking them. With the less 'boisterous' pupils, particularly the females, there was explicit expression of appreciation for making them aware that there was much room for improvement within their performance. Some of their male counterparts, however, evoked an aura of nonchalance, seemingly in an attempt to hide the fact that they have become aware of some 'flaws' in their constant 'excellent performance'.

A comment common to all subjects was their expectation. They all 'expected something'. Although the expectations differed from person to person they all expected either to be tricked, the same as all examinations, expect that in a normal examination this, that or the other would prevail etc. The presumptions which pupils are conditioned to bring into an

examination room is bizarre.

One subject documented the following at the back of the answer sheet after completion of the interview and discussion: "I figured out **how to figure out** what glucose is. I am normally very confused with the diagrams of sugar molecules. I find it hard to identify them."

4.7.3 GENERAL CONCLUSION

The deficiency of skills is apparent in these pupils as well. Since these pupils represent part of 'the cream of the crop' of Braintree High School it stands to reason that most other pupils would be lacking same and may be even in a worse situation. All the more reason for a concerted effort to made in the direction of teaching thinking skills in schools as early in the school career as possible.

4.8 FEEDBACK FROM MY PIONEER GROUP

I have interviewed seven matric pupils during 1989 as part of previous course work. All of them are currently affiliated to tertiary education instutitions. During late July - early August 1990 these subjects were issued with 'response' forms. Six of these were retrieved. Due to lack of time and organisation on my part I failed to retrieve the last one. At

the time I have been very busy 'wrapping up' my research at the high school and simultaneously organising my affairs for a smooth departure. I did not have much time and in the rush forgot about the last response form. I do not think, however, that it would make a big difference to what I may find from these reports.

4.8.1 THEIR INTERVIEW BACKGROUND

This was the group I had used to determine **which skills** were present or lacking in most or at least some final year high school pupils. The first subject had 117two117 person-to-person interviews and **one** Pair-Problem-Solving session. His partner in the latter had one person-to-person interview and so did the remaining five. After each interview I had an in-depth discussion with the subject and tried to satisfy their curiosity with my limited knowledge at that time. I had given the transcripts of some of the subjects to read and if they wanted to, which they did, they could exchange transcripts and try to learn from the others. I had also given some of them the analysis of the interviews as well as part of the work based on the interviews. They had a good idea of what the interviews were all about and wished to have more, but it was too close to their final examinations.

Subjects were asked to share their experiences with the others in their class to give them a chance to exercise what they have

learnt. I had some enquiry into cognitive instruction from this group after their interviews as well as from few others. This was an indication that the topic had been discussed. I helped them as far as I could. Below follows the report which I received a year after the interviews.

4.8.2 REPORTS BY THE PIONEER GROUP

The fields in which these subjects find themselves currently differ for everyone of them, from Medicine to Commerce and Engineering. Three of these subjects obtained A-aggregates in their matric examination at the end of 1989. The others are as follows: B, C, E. This allows me to have much confidence in their feedback which I would summarise under the heading supplied in the 'response' form.

1. INFLUENCE ON MATRIC RESULTS

Most of the subjects reported that they do not know whether the interview had any effect on their achievement in the final examination. One claimed that she was under so much pressure to get through all her work which she swotted up like usual. She is not sure whether she had applied these skills subconsciously. Most of the subjects said that they had worked very hard the way they had done in other examinations and that in their panic there was no time to think of these skills. Only one subject

reported that he can attribute his relative success in Biology and Geography which he took on the Higher Grade to the application of the skills he had learnt during the interviews. He used to be an achiever in lower standard but since standard eight has dropped drastically. He feels that the interviews helped him organise his approach to his study much better.

2. WHICH SKILLS DID THEY LEARN

The subject discussed last in the paragraph above maintains that graphically or schematically representing given information helps him to orient himself spatially. Labelling sketches with abbreviations while examining it is very useful when having to draw on these sketches for information. The subject now doing medicine displays great memory ability and has a vast amount of knowledge in the field of Biology. She attributes her ability to quickly arrange all the information on a given topic in a limited period of time to the interview she had. Arranging information logically, for most of the subjects, was the skill which they had learnt. Commerce student finds the analytical skills which he had acquired particularly useful when dealing with the many MCQ-tests in his field.

The Arts student feels that thinking aloud allows her to generate more thoughts. This she feels, leads to the **illumination of new skills.** (I am not sure what she means by this). She sees abstract issues more clearly which allows her

to rationalise about these issues. She has also learnt the skill of **comparison** which, at this stage should have been part of her normal cognitive operations. Although the others did not mention this I have noticed the absence of spontaneous comparative behaviour in all the subjects. The importance of working from the basic concept to the finer details was also mentioned.

3. HOW ARE THEY CURRENTLY APPLYING THE SKILLS

One subjects claims that he is working hard to understand basic concepts first and then fill in the detail. This would make his approach more organised. The following I quote from the Arts Lady: "University is a far cry from any scholarly institution....You find yourself wrestling with a problem in English (probably literature), trying to seek deeper meanings ..... by comparing, rationalising and plain insight you find your own solutions." I would deduce from here that she is working hard at trying to solve her problems without the help of a tutor. Logical, analytical skills are applied in subjects like Accounts, Statistics and Economics. Many subjects apply these skills when reading questions, particularly the the Medical student who applies it in Human Biology and Anatomy. She feels that she needs 120much more practice120 in these skills before she would be able to apply it spontaneously. The Schematic or Diagrammatic representation of data and organising information into headings and subheading or just paying

attention to these if there are any helps the Engineering students. All of them, at some place in their reports, mentioned the fact that it is useful in everyday life and that they probably apply it there mostly!

4. RECOMMENDATIONS BY SUBJECTS

Being uninformed about exactly what is going to happen makes it exciting for the subjects and they feel it should be kept that way. It also allows them to find out how much or how little they know about a particular topic which they have already covered. It allows them to participate more spontaneously without any inhibitions. Two subjects did, during the interview, appear inhibited as they did not want to make 'stupid statements'. As for the others, they understood that **everything** goes and that I was not going to grade their papers.

One subject feels that the interviews initially should be based on more general questions and not be related to any of their curricular content subjects. Subsequent interviews could gradually build up to their school subject matter. More sets of "Unseen Questions" should be given on a varied basis without any help from the teacher. The questions should become more difficult each time. This would force the subject to **think more than usual** . They want to see a 'progress picture', the **BEFORE and AFTER** as one of them put it.

5. GENERAL COMMENTS BY SUBJECTS

One derived the bit of career advice that it is **NEVER** too late to change the direction in which you are studying. He applied and was accepted for B Comm. but is actually studying Mechanical Engineering now. Another, who did not comment on this, applied for B Sc. but is currently registered for B Comm. The stimulation of their mental faculties and the opportunity to express their views and formulate answers in the words which **THEY** understood was enjoyed by many. It is a good method for inducing analytical skills. Everyone feels that more people should be exposed to this type of problem solving skills since it is very useful in everyday situations and life in general.

I shall end this section with the following quotation from one of the reports: : "I had the chance to find out how spontaneous I could be and how much I actually knew without preparing for that particular situation. I hope I would be able to build on what I have learned and I hope that whatever this research is about, that I... could have contributed and that others may benefit from this interesting method of self-evaluation."

C H A P T E R 5

THE SIGNIFICANCE OF THE INVESTIGATION

5.1 REFLECTION ON THE RESEARCH - A POST-MORTEM

The Cognitive Skills identified as deficient at the beginning of this investigation which were taught during the programme clearly require the attention and time this study has devoted to it. It appears from the investigation that it is necessary for these skills to be taught explicity, yet integrated with the normal class activities. Pupils do not generally develop these skills on their own (refer citation from Arons on p 16). Cognitive growth in every field is dependent to some degree on skill development (Novak, 1977:155) thus the teaching of these skills is absolutely essential for the development of the cognitive structure of the child.

EXPERIMENTAL GROUP 1

Teaching these skills in concentrated form over a short period of time as an entity separate from everyday class teaching did not seem to have a positive effect on the E-G 1 in short term. This group was subjected to the kind of treatment described above and did not perform well in the 'qualifying test'. The intense instruction seemed to have worn out the pupils. At the least the subject could forget about the exercising of skills for a while and get on with solving the problem 'the old way'. This pattern surfaced in the study of the PIONEER group's

feedback reports. They had no time or did not apply the skills in the preparation or during the examination but most of them are currently applying these skills at the tertiary level of study. The only subject of the Pioneer group who admitted to applying the skills is the one who had an interview and Pair-Problem solving session early in 1989 and was never bothered with the 'skills story' again. He attributes his relative success in Biology and Geography to the skills he had acquired during the sessions of cognitive instruction. It appears as if the skills have to be introduced subtly and integrated if the time for its required effect is short. On the other hand, the pioneer subjects report of benefiting now (after a year) from the interviews they had. I think the IN-DEPTH discussion after the interview and some follow up reminders had much the same effect as the deliberate programme of instruction administered in this investigation.

Based on the above information it is possible that E-G 1 would be good problem solvers some time later in their studies. Novak (1977) asserts that if instructional programmes allow each student to achieve his potential the small initial differences in cognitive development could become enormous over a period of twelve or more years of schooling. He states, however, that this conjecture is purely theoretical. Evidence is slowly being gathered to substantiate Novak's speculation as more information on studies in the the field of cognitive instruction

becomes available.

It is also possible that the E-G 1 experienced COGNITIVE OVERLOAD as described by Perkins (Chipman,1985) which acted as a source of proactive interference at the time of the final test. According to Perkins this cognitive load may act as a hindrance at least until some automatization occurs. Robbie Case (1980) asserts that the maximum number of items a child can coordinate at any one moment is referred to as his/her working memory. Within each stage of development the working memory for the type of task is characteristic of that stage of development. This working memory develops very slowly, in response either to maturation or massive practice in executing the basic mental operation of the stage (Kirby & Briggs,1980:34). It is possible that in the case of E-G 1 the subjects had too many cognitive functions or tasks to deal with at the same time.

The many authors like Beyer, De Bono, Feuerstein, Lipman, and Whimbey who advocate the direct teaching of thinking skills (Costa,1985:20) have the idea of a school wide programme or a special time allocated to this instruction. At this stage in our school situation it is not possible, although it would be sensible. What could be opted for now is teaching these skills directly during eg. a social science studies unit or any subject in which the teacher specializes. The qualities of

fluency and metaphorical thinking might be taught directly during creative writing etc. (Ibid). The E-G 1 could have been exhausted by the extra hours as the cognitive instruction was done as a separate subject in concentrated form for about four months in addition to the full quota they already had.

EXPERIMENTAL GROUP 2

Having successfully integrated the cognitive process instruction with the normal running of classroom activities, the E-G 2 seemed less exhausted and less 'concerned' about strategies and skills, although they were applying these. They had performed much better than the E-G 1 but in time, maybe in the next year, the Subjects of E-G 1 would have gained more confidence as the skills become part of their daily applications (cf. Purser & Renner,1983:96; reports in Chapter Four on Feedback from the Pioneer Group).

As stated earlier the subjects of the Pioneer Group were floundering on the edges of formal operations, still anchored by their concrete operations. According to the Piagetian Scale, they should have been far more adept with the formal operations. This discrepancy clearly shows that these pupils do not perform at optimal capacity as yet and that chances are that they would be able to benefit greatly from Cognitive Instruction.

Alan Schoenfeld (1985) describes a similar study in which he investigated five heuristic procedures in mathematical problem solving. He introduced the heuristics to his experimental group during the problem solving activity and not as a separate entity. His study showed that the students of his experimental group fared much better in solving problems comparable, but not isomorphic to, the problems they had worked with during the instructional sessions. His control group, which did not display the same flexibility in problem solving, was not exposed to these heuristics. This study of Schoenfeld supports my finding that the heuristics to be applied in a short period should be integrated with the material it is meant to be used for.

5.2 THE SIGNIFICANCE OF THIS STUDY

In a book by Tiedman published in 1787 the author stressed the importance of an exhaustive study of one child, since "it informs us of one among the possible rates of progress and allows us to put some determination upon the previously indefinite subject" (Navarra,1955:3). The research undertaken in the case of this current investigation involved many individuals as well as groups. The findings should provide us with some information on the cognitive operations of groups of pupils who were subject to different types of teaching programmes. It should also shed more light on how the

individual's cognitive operations compare with that of the rest of his/her group. Teachers could use these findings to structure their teaching aimed at the group, yet addressing individual cognitive differences. A summary of the activities and outcome is provided in the previous chapter.

Many different arguments may be raised for the differences in performance of the three groups and the changes which occurred within the individuals of these groups. It is my opinion that the cognitive skills which they have learnt have enabled their effective use of the information they supplied. De Bono has run a good number of experiments with various groups in teaching thinking. He has the following to say about his experiments: "The experiments do not succeed in proving anything, because in each case it is always possible that a special set of circumstances biased the results. ... Much work is still going on in this area and much work remains to be done." (De Bono,1980 :243)

The scope for research in this field is still wide open. This investigation could serve as a basis for further research into his field. The aim of this paper, to provide some illumination on concept formation and integration of knowledge in Biology, has been realised. I hope this paper will be of benefit not only to researchers in this field but also to practising teachers wanting a different approach to teaching Biology.

The enthusiasm displayed by all participants throughout the

investigation and the strong positive feedback from them them served as inspiration for the launching of the next investigation. Operation Cranium Commander is my latest field of research, an attempt at introducing Cognitive Instruction into High Schools in the Cape Flats.

5.3 WHERE DO WE GO FROM HERE ?

5.3.1 POINTS TO CONSIDER

If we always remember that children are not blank slates able to receive instruction in a neutral way but approach experiences presented in science classes with previously acquired notions half the battle is won. These notions influence what is learnt from new experiences in a number of ways (Driver et.al.,1985:4). As cited before, Gunstone and Watts brought forward the idea that these notions are held firmly and are often resistant to change (Ibid:102). We also have to remember that concepts do not develop in a closed system but are in constant interaction with each other - even though for methodological reasons they are studied separately (Inhelder, 1979:15).

It is for this reason that I feel so strongly about integrating the concepts relating to a particular topic and as Inhelder et. al puts it: "it is this interaction that accounts for the child's progress during learning experiences." (Ibid). The

authors further state that fundamental concepts derive from coherent systems of mental operations, consequently, they cannot be separate entities. Grasping one of these implies the understanding of the others. Acquisition of these concepts takes place very gradually and opens the way to new discoveries (Ibid :27). It is from this premise that the analysis of the items in the test was done. The understanding of some concepts, not the definition thereof, was important in the analysis and pupils being able to describe process, events or phenomena in their own word show greater insight into the concept than those memorising often ill-phrased or vague definitions.

The definition of HOMEOSTASIS, for example, is misleading not only in the textbooks we use in our schools in the Cape but referring back to Chapter Two some work cited by Barrass highlights misconceptions perpetuated by textbooks and teachers of Biology.

Another factor to consider is the learner himself. According to Gagne et. al.(1988:97) the range of learning tasks is undertaken by learners who themselves exhibit diversity that is enormous in scope and detail. The learners who approach the new learning tasks are all quite different in their characteristics as learners. Some qualities of the learner are innately determined, eg. visual acuity, which is a built in function of

the human individual and although it can be aided by artificial lenses it cannot be changed by learning. Such properties needs to be considered in instruction by eg. avoiding fine print or fuzzy projection. For these and other learner characteristics that are genetically determined, instructional design cannot have the aim of altering these qualities by means of learning (Ibid: 98).

The level of development of the learner on the 'Piagetian scale' has to be assessed prior to devising a plan of action. Since chronological age currently is not indicative of any cognitive developmental stage the assessment is vital to the success of any programme. As I have mentioned earlier, most of the 16 - 18 year olds with whom I have worked thus far have still not found firm foothold in the formal operations sphere.

In teaching scientific concepts it is essential to take account of the nature of their spontaneous precursers, i.e. to explicitly contrast the two sets of criterial attributes and to indicate why the adoption of the more abstract and precise is preferable (Ausubel,1968:529). School age children through adults learn new conceptual meanings by being presented with the criterial attributes of concepts and by relating these attributes to relevant established ideas in their cognitive structure i.e. by the process of concept assimilation. It is essential when planning to confront an individual in a teaching

situation with new concepts that the instructor is aware of the operational level of his charge. The instructor could then try and accomodate the learner by adapting his information and method of instruction to the level of the learner. Since it is important that a basic concepts are acquired at an early age and should be done with utmost care and intensity I feel it necessary to refer to the younger school child this stage.

Concept formation is characteristic of the preschool child's inductive and spontaneous acquisition of generic ideas such as 'house' 'dog' etc, from concrete empirical experience (Ausubel, 1968:510). As they grow biologically and cognitively the level of the concepts they attain becomes higher and they need a different means of acquiring these new concepts. Within the limits imposed by their developmental readiness, systematic verbal instruction in abstract concepts, combined with appropriately used concrete-empirical props, is pedagogically feasible and can greatly accelerate the acquistion of the higher-order concepts (Ausubel, 1980:529)

5.3.2 THE WAY TO GO

This paragraph is not intended to supply a one way road to success. As is often stated : **"THE ROAD TO SUCCESS IS STILL UNDER CONSTRUCTION"**. This section is aimed at providing a few more 'tools' to aid this construction. This road is so greatly

forked as there are many ways to achieve success. The individuality of our pupils has a lot to do with this 'forking' phenomenon. Garrett (1986:79) reports from Thorsland and Novak (1974) that there is some indication that this diversity of individuality of problem solving is retained across tasks. It is important, then, that teachers communicate with each other to establish what is known about the learners in order to accomodate these learners in their various tasks.

Clough and Driver (1986:489) reports similar findings of common patterns of conceptual frameworks from their investigation into understanding of some scientific concepts. They further suggest that it is possible for educators to anticipate some of the common frameworks likely to be present in students of a particular age group. According to Biggs (1985) the data encountered during learning is encoded at various levels. The topmost of these levels is determined by the existing HCS (Hypothetical Cognitive Structure) of the student.It is important for teachers to familiarize themselves with these patterns of conceptual frameworks which exist in the minds of their pupils to facilitate learning as a more pleasant experience.

The 'common frameworks' which teachers currently address exists but in a small percentage of the pupils. It is the framework to which the school syllabus is geared. It is important that

experienced practising teachers become part of the group who decides on curricular activities. To make the activities more relevant and practical is surely going to be a painful transition for administrators and educators; but who are we trying to serve? If we do not act fast we stand to loose a great deal in the future. We have to try and save the situation and teach the children to cope with their lives and help them build a brighter future. Ravitch and Finn, who has investigated what American 17-year-olds know, observed the following:

> "We do not assert that American 17-year-olds are stupid, that they are apathetic, or that they are short on savvy, creativity, and energy. We do not contend that the 'younger generation is going to the dogs.' We merely conclude that it is ignorant of important things that it should know, and that it, and generations to follow are at risk of being gravely handicapped by that ignorance upon entry into adulthood, citizenship, and parenthood." (1987:201)

There is thus much evidence to indicate a need for upgrading the type of teaching occurring in the classroom. The improvement of the quality of teaching, rather than the quantity of content, should enjoy priority at this stage.

The introduction of Cognitive Instruction is thus strongly suggested as an integral part of all subjects at the earliest possible stage. The great success story of Prof. Olney's Where there's a Will, There's an 'A' has hit American Television with great force last year. Promoting this Three-

Part Series, primary through tertiary levels, was John Ritter, a comedian most of the youth identify with. The acquisition of Thinking Skills is enjoying much attention in America. As mentioned in paragraph 2.2.2 of this paper an attempt is being made by some individuals and organisations. However, the DEPARTMENTS of EDUCATION has to take the lead and make the task of these bodies easier.

It would be difficult to teach Cognitive Skills as a separate subject to primary school pupils. However, the basis can be laid there by integrating these skills with the daily activities and gradually create an awareness of these skills toward senior primary levels. Having a basis for deliberate acquisition of these skills Cognitive Instruction can be taught at least one period a week at secondary and tertiary levels. Since the time for these skills to 'settle in' is about five years before the pupil leaves high school it is advisable to learn these skills as a separate entity. Should, at the time of implementation into schools, any matriculants would want to learn these skills to aid their performance in the final examinations these skills should be introduced subtly, integrated with subject matter. This implies that each subject teacher should be able to deal with cognitive instruction. The cue is taken from the way E-G 1 and E-G 2 responded to their different circumstances.

I suggest that a country-wide research programme be conducted

in South Africa to explore the possibility of introducing Cognitive Instruction as a separate course in secondary and tertiary institutions. In addition to learning cognitive instruction as a separate entity each subject teacher should be educated in this field to enable them to draw from these skills to help their pupils solve problems in a specific subject context. Thus the cognitive skills are acquired separately but it's application and practice is transfered to all their curricular activities. This calls for teacher training, in-service as well as in training colleges. The work of Soar discussed in Chapter Two and Chuska's K-12 Programme could be used as a basis for teachers. Although many programmes proclaim that special teacher training is not required but recommended I suggest it best be a requirement as most teachers, when unfamiliar with materials, avoid it completely.

Schoenfeld (Lochhead,1979:319) contends that learning to use a particular heuristic, even under ideal conditions, is far from simple. I would hardly imagine an uninformed teacher as fitting into this pattern. I would be a situation far from ideal which could only make the learning of the heuristic more difficult. Schoenfeld further notes (Ibid) that illustrating the heuristic in one or two examples is insufficient and that the student needs to see the heuristic applied in as many contexts as possible. For a teacher to come up with the various applications of a particular heuristic means prior practice by

the teacher. This further indicates the importance of training teachers in this field. In my concluding paragraph of Chapter four I have cited from the report of one of the Pioneer Subjects stating that she would need much more practice to be able to derive full benefit from the Cognitive Skills which she has learned.

Bellanca (Costa, 1985) asserts that we hear much talk about students acquiring higher-level thinking skills. He contends that this occurs most successfully when a teacher uses higher-order teaching skills. He suggests that teachers use very refined questioning skills to draw out and extend responses, especially from reluctant learners. This further support the need for special training of teachers.

One of the first skills which pupils will have to learn is proper reading skills. Many programmes directed at Reading Skills are mentioned in Chapter 2. Since much of formal instruction is done via written media pupils will have to be equipped to deal with this medium as effectively as possible. After all, it is the educators who have created this medium for the learner. According to Athey (Guthrie,1979:94) reading is an activity in which the highest human abilities, viz., perceptual, intellectual, and linguistic, interact and support one another in the pursuit of a single goal. This goal is the processing and assimilation of written information. Otto (Ibid:193) is

convinced that the most straightforward way of developing reading comrehension is through the development of subskills. Teaching the little things which teachers often take for granted becomes important at this stage. To facilitate the understanding of written material the learner should be able to manupilate the information given. They should be able to reason about the given information. Nickerson et.al. (1986:131) proposes useful tools for reasoning. These include diagrams, truth tables, symbolic logic, decision trees, and so on. Although these do not guarentee effective reasoning using these, he suggests that they can be useful nevertheless. He further notes that as with any other tool, learning to use reasoning tools requires considerable practice.

5.4 THE PRINCIPAL'S ROLE IN ENHANCING THINKING SKILLS

Costa (Maxwell, 1983:211) asserts that the role of education in developing intelligence will best be realised if an integrated curriculum is adopted. The component parts would have to be tuned to work harmoniously to produce the desired results. In my opinion this refers not only to content but also to the administrators of the content. I have already made reference to the role of the teacher and possible ways in which to have teachers acting out their roles. It is important that the 'head of the school' also be educated in this respect. McTighe and Schollenberger (Costa, 1985:11) asserts that education of the

intellect must be installed as a value of the school and the community. They extend the parameters to include teachers, parents, administrators, board members, and the community as a whole. These parties should adopt thinking as a basic goal of education in order to shift the current emphasis of teaching and a list of ways in which this new approach can manifest itself in the community is furnished.

The ideas which Costa (1985) holds and explains so thoroughly in his article 'Teaching for, of and about Thinking' stirred me greatly. I have drawn extensively from this article to highlight the role of the school principal in the changing situation. Costa asserts that if teachers are expected to teach for thinking, they need an environment in which their intellectual processes are stimulated. The principal should create at school an atmosphere that invites teachers' highest intellectual functioning. Costa furnishes the following ideas which would allow them to create this stimulating environment.

Principals should

1. Involve teachers, parents, and students in decision making. Encourage, facilitate, and protect teachers' right to

   * Pursue self studies
   * Develop goals
   * Plan personal staff development
   * Prioritize which thinking skills to emphasize
   * Select their own instructional materials
   * Invent methods to determine their own effectiveness
   * Determine indicators of student growth
   * Share and suggest solutions to problems

2. Employ collegial supervision rather than evaluation. According to Costa making value judgments is another way of inhibiting thinking. Value judgment detract from motivation and produces stress. Under stress the brain's creative, analytic functions are extinguished and replaced with conformity.

3. Avoid recipes. Costa describes the situation currently existing by exposing that principals find it tempting to evaluate the act of teaching in "**five steps, four factors, and seven variables**". He asserts that teaching and learning the **complex strategies of higher level thinking** are more lengthy and dignified than that.

4. Explicate THE DREAM. Costa holds the opinion that prinicipals of effective schools have a vision of what their school can become. In order to achieve that vision they constantly assess all programmes, each decision, and every new direction in order to help achieve that vision.

5. Constant reminders. Costa forwards the following type of reminders which could keep teachers and pupils reminded of the vision of the school. The school's memo-pads may be headed by "**Thought is Taught at ...High School**" and sound such as "The Hots (Higher-Order Thinking Skills) Committee will meet in the teachers' room at 3.30" may echo in the hallways.

Currently, when schools do not achieve what was 'expected' or do not make the top of the list, principals find someone or something to blame for the situation. John Holt (1982:8) documents some attitudes that prevails at effective, successful schools:

> "(1) ..if the students did not learn, the schools did not blame **them** or their families, backgrounds, neighborhoods, attitudes, nervous system, or whatever. **They did not alibi.** They took full responsibility for the results or nonresults of their work. (2) When something they were doing in the class did not work, they stopped doing it, and tried to do something else. They flunked unsuccessful methods, not the children."

It is high time that a move is made away from the current stale-mate' situation we have so comfortable snuggled into and start gearing ourselves to work. To work on ways of avoiding a possible 'check mate'. If we wait for such time before we react we sure have committed educational suicide.

5.5 A NEW CURRICULUM?

Costa's view on an integrated curriculum has been noted in the above paragraph which I feel has to be considered here again. The term 'integrated curriculum' may have different connotations to different people. A personal interpretation has already been given above. Further elaboration, however, is needed here. Installing a new curriculum implies change.

Citing Ruggeiro (1988:14)

> "Like most valuable changes in curriculum, the addition of thinking objectives to a course will cost something. The cost in this case is a sacrifice of smoothness and neatness of instruction. Teaching students by the methods we will discuss in this book will be different from teaching them by lecturing. So teachers who have grown accustomed to lecturing will for a time experiencee the awkwardness that comes with any new approach, and even after they acquire skill in teaching, they will have to contend with certain inevitable difficulties. It is more difficult to lead students in discussion than to lecture to them, and more difficult to maintain classroom decorum when students are animatedly exchanging views than when they are quietly slumbering. Similarly, it is more difficult to keep precise pace with the syllabus in a dynamic situation than in a static one."

Changes that have to occur affects not only the content but also the people involved in processing the content; that is the teacher as well as the learner. These changes seem to be way overdue. Possible reasons for the delay are the attitudes of teachers to a new method of teaching. The new method should aim at accomodating individualised instruction, 'putting the pupil first'. The teacher may feel strongly against such a change for the reasons forwarded by Gagne et. al (1988:309)

> "At first glance, the task of storing, arranging, and using models for instruction may lead one to believe it is all more trouble than it is worth. Indeed, teachers need training in how to manage individualised instruction. At first such training may lead the teacher to feel that his most cherished functions are being usurped by the system and that he is being asked to perform only the task of a librarian or clerk. This is because some of the teacher's tasks are new and strange compared with those required under a conventional method of teaching. All teachers need special training for conducting and managing individualised instruction and they cannot be expected to function adequately, let alone enthusiastically, without such training."

Enough evidence is available to substantiate the fact that special training is absolutely necessary for the smooth running of a programme in cognitive process instruction. The importance of this process being to allow pupils to operate more independently to facilitate the process of discovery learning. Ausubel (1968:22) expresses the following views of discovery learning:

> "The essential feature of discovery learning, whether concept formation or rote-problem-solving, is that the principal content of what is to be learned is not given but must be discovered by the learner before he

can incorporate it meaningfully into his cognitive structure."

5.6 CONCLUSION

The directives supplied in this chapter should be considered seriously and be put to test. It is unfortunate that it is not possible to simply approach some of the people and institutions in question and put the proposals for implementation. It would make the process of introduction of Cognitive Instruction in schools so much easier.

In the ensuing chapter I shall provide an overview of the aim of this investigation, briefly mention some of the important aspects which became evident during this investigation, and also provide a synopsis of the recommendation on the basis of the investigation.

C H A P T E R 6

CONCLUDING COMMENTS

6.1 AN OVERVIEW OF THE INVESTIGATION

This investigation is aimed at identifying the Cognitive Skills which would facilitate adequate concept formation, particularly in the field of Homeostasis, an aspect of Human Physiology. These skills, once mastered, should not only be applied to Homeostasis but should be transferred to all fields of problem solving. Some of the subjects if the PIONEER GROUP reported of these skills being particularly useful in everyday problem solving.

Ways in which to teach these skills has also been investigated. The conclusion is: On a short term basis these skills should be very well integrated with the normal teaching. Much practice should be experienced in the field where it is required. On a long term basis, i.e. there are a few years available before these skills become vital, these skills could be studied separately, being a unit on its own. Subject teachers can then draw on the skills already part of the Cognitive Structure of the pupil and make it applicable in his/her field. These teachers would not have to spend time teaching these skills which could lead to a loss of time for teaching content. Having to do both activities in the time allocated only for content could place strain on both teacher

and pupil.

A new curriculum would be the answer to effect the necessary changes in the structure of the education of the pupil. This topic has been extensively covered in the previous chapter. A few words in this respect would be mentioned in the last paragraph.

6.2 WHAT CAN POSSIBLY BE ACHIEVED

It is not the aim of this investigation to produce a reserve of "Doogie Howsers". The D-H phenomenon is healthy only if the person involved has the inherent ability of such rapid progress in such a short time. Many parents, however, push their children, pursuing this dream for **their** satisfaction. These parents want to boast about the over-achievement of their under-developed children. The citation of John Holt (1982:2) (Ch 2, par 2.4 of this paper) should be borne in mind by **all** caregivers of children, particularly their own parents.

It is most often not an easy task convincing a parent that their precious little child is operating at optimum capacity; that increased pressure could have disasterous effects on the performance of that child. From a parent's point of view an intervention may be necessary and parents often feel that "low achievement" by their charges is due to non-intervention on their part.

It is therefore necessary to involve interested parents in as many school activities as possible and in this way maybe stimulate those parents not so interested. Adequate exposure of teachers to the parents of their pupils and vice versa should lead to a more balanced view of the pupil by both parent and teacher. Also close cooperation between parent and teacher should ease the task of the pupil should any problem arise at school or home. Both teacher and parent could broaden their insights into the pupil's capabilities and limitations in various fields. Much of the frustrations which pupils suffer due to a lack of understanding by their elders could be alleviated in this way.

Involvement of the parent should be one of the priorities of schools where this facility is still lacking. This could have the secondary effect of avoiding the often heavy clashes between teacher and parent as result of a lack of communication of which both parties are guilty. Parents may learn to trust the judgment of teachers and accept the fact that the "Einsteins" are but a small minority of the human population.

As discussed in the previous chapter the education of teachers in respect of Cognitive Process Instruction should become the priority in the Education Departments. It is impossible to have pupils

acquiring these skills if the teacher is not familiar with the various cognitive skills. The need for these steps has been clearly demonstrated by this study. With more enlightened teachers there is a greater chance for the balanced development of the pupil. This could result in fewer pupils experiencing behavioural problems. The teacher would then have more time available for actual "building up" activities rather than for "breaking down" activities. The latter refers to the "remedial" or "reformative" action teachers often have to take to "bring the child back in line". Inevitably a healthier generation of youth would be produced resulting in a healthier community. The community would have better problem solvers. Thus there would be better planning, administration, and better execution of the various tasks involved in community life.

6.3 OTHER GUIDELINES

Starting at primary school level some of the more basic Cognitive Skills should be introduced to pupils at all levels. If these are learnt early in life it becomes part of the pupil's normal operations. By the time s/he reaches secondary school s/he would be quite adept at the use of these skills and would be ready for the higher order Cognitive Skills which is required for problem solving at secondary school level.

A detailed guide for the teacher in both primary and secondary level should be devised to aid the teacher in teaching these skills. A continuum should exist between primary and secondary school. At senior secondary level Cognitive Instruction could be offered as a separate subject. At tertiary education level, which includes the education of prospective teachers, the course could also be offered as a separate subject. At least one year of Cognitive Instruction at tertiary level should be made compulsory to enable these teachers to teach thinking skills when they start teaching in schools.

Many Education Interest Group which are currently operating and running workshops could include Cognitive Instruction as one of its topics. Maybe two to three workshops could be devoted to Cognitive Instruction per annums. The creative element should not necessarily come from the top down, i.e. the Education Department telling teachers what to do. Teachers could organize themselves and share ideas on CPI and they do on other aspects of their teaching.

Most important of all the principals of schools should be involved in the teaching of Cognitive Skills. A scheme of the role school principals could play has been clearly outlined in paragraph 5.4 in Chapter Five. A good way of making school principals aware of

this important aspect of the pupil's development is to involve interested and motivated principals to have their schools operating as models for less fortunate schools. Few principals are aware of this new dimension in education. Once principals know the advantages of Cognitive Instruction I am sure that these principals would go to infinite depths and lengths to improve conditions for the pupils as well as for the teaching staff.

The more people, be it school principals, teachers, parents, or pupils, that can be involved in spreading an awareness of the advantage of learning Cognitive Skills the more can be achieved in a shorter time. The cultivation of Cognitive Skills should, after all, be a community effort as it would be to the benefit of the community as a whole.

APPENDIX 7 (a)

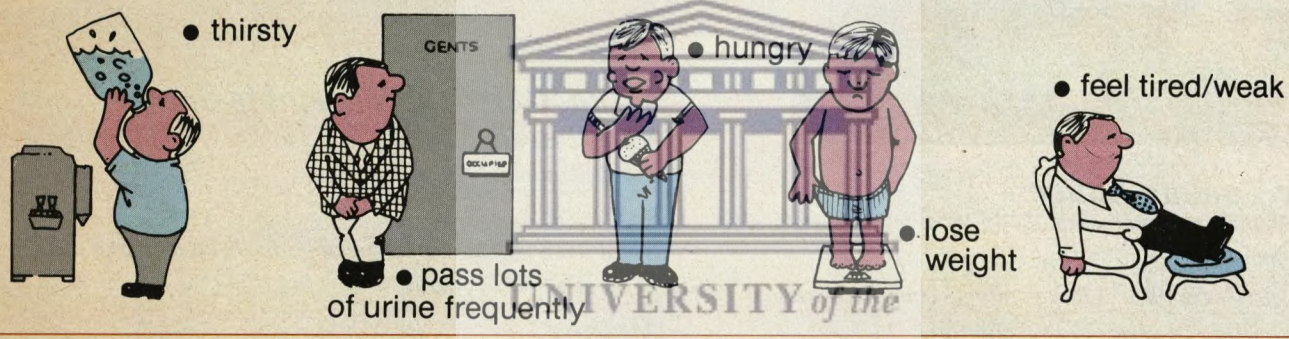
What is Diabetes?

Diabetes (often called sugar diabetes) is a condition of the body, where sugar is not used correctly to provide energy for living and growing.

What happens in the body?

INSULIN CARRIERS SUGAR from the blood to the cell to provide energy for the body. A gland called the pancreas makes Insulin. In Diabetes the PANCREAS FAILS to supply enough effective Insulin.

How would you feel if you had Diabetes?



OTHER SYMPTOMS

• changes in vision • numbness in hands and feet • slow healing cuts or bruises • itching

Some people with Diabetes have no symptoms at all

How is Diabetes Treated?

FOOD + ACTIVITY or ***FOOD + ACTIVITY + INSULIN*** or ***FOOD + ACTIVITY + TABLETS***

Accepting that you have Diabetes must come first. Understanding the disorder will then enable a Diabetic to achieve good control and adjust to a reasonably normal healthy life.

What you should know about Hypo Reactions or Insulin shock

If the BLOOD SUGAR LEVEL of a DIABETIC falls too low, the result may well be HYPOGLYCAEMIC REACTION (a "Hypo").

Symptoms of a reaction

- nervy
- headachy
- shaky
- cranky
- confused
- hungry
- slurred speech
- nauseated
- sweaty
- clumsy
- coma

Cause of reactions

- too much alcohol
- exercise without extra food
- too much insulin
- being late with or missing meals or snacks
- not eating enough carbohydrate

APPENDIX 7(a)

COOKING THE PASTA CORRECTLY

- It is essential to have abundant boiling salty water to cook pasta. There is only one way to cook pasta - and that's "al dente" which literally means "by the tooth". You should add a little oil to the water to prevent pasta from sticking together.
- Fresh pasta takes about 5-6 minutes to cook and dried pasta from 9-15 minutes depending on the shape.
- Once the pasta is ready, strain thoroughly in a colander, toss in the pan with your favourite sauce, sprinkle with lots of cheese and eat hot. A cold pasta is very bland and loses all its character. If you do not have enough sause prepared for the quantity of pasta cooked, add a blob of butter to pasta while tossing - which will also prevent sticking while preparing extra sauce.
- Italians from the North of Italy prefer creamy, cheesy sauses, while Southerners enjoy tomato based sauses with plenty of spices and a strong flavour. There is no doubt about it, pasta is healthy and no matter what sauce you choose, you're sure to enjoy it.

BELOW:
Ingredients for following sauces: Basic tomato sauce; Chilli & salami; Tuna, celery & vegetables; Basic cream sauce

Basic Tomato Sauce

1 kg fresh mature tomatoes or 1 x 450grm can chopped, peeled tomatoes
1 stick celery - chopped; 2 large onions - chopped fairly big
4 cloves garlic - chopped; 124 ml olive oil
salt and pepper to taste; 1 bay leaf or fresh basil

Method

- In a large pot, add your oil, onions, garlic and celery, bay leaf or a handful of fresh basil.
- Leave to sweat for about 10 minutes.
- Then add the tomatoes finely chopped, and season with salt and pepper.
- Leave to simmer for a good hour.
- When the excess liquid has evaporated, pass through a vegetable mill and use as directed for other sauses. Delicious to serve with pasta as is - hollow-shaped pastas are preferable. Serve with plenty of parmesan.

CLOCKWISE L - R:
Tuna, Celery & Vegetable; Cream & Chicken; and Chilli & Salami

Chilli & Salami Sauce

You'll need to fry

a chopped onion
some garlic
a fresh red chilli
and about 15 slices of salami cut into strips (use about 3 tbls of oil to fry the onions in).

Method

Cook for about five minutes and then add in your basic tomato sauce and cook for a further twenty minutes. Season with crushed pepper.

Tuna, Celery & Vegetable Sauce

You'll need

chopped onions
some garlic
sliced fresh vegetables - ie green beans, baby marrows and perhaps a firm eggplant

Method

Fry the above together for about five minutes and then add a can of Tuna fish "in oil". You may add the tomato base now and here too there is a cooking time of about twenty minutes. Just before serving add a good amount of chopped parsley.

Basic Cream Sauce

You'll need

A finely chopped onion
100g butter
either bacon, ham, chicken breasts or mushrooms - sliced into strips
1 tbls flour
250 ml white wine
250 ml fresh cream
salt & pepper to taste

Method

Fry the onion in the butter until transparent and add either the strips of bacon, ham, chicken breasts or mushrooms (whatever takes your fancy) and fry further. Add the flour to help thicken the sauce a little. Add the white wine and simmer until evaporated. Finally, add the cream and cook for a further ten minutes. Use the sauce immediately - adding some fresh chopped sage.

PICK 'N PAY BREAD POLICY

IN-STORE BAKERY - STANDARD BREADS

We guarantee that standard loaves of bread (i.e.800g), baked by our in-store bakeries will be at a minimum of 800g baked weight.

INDEPENDENT BAKERY - STANDARD BREADS

We guarantee that standard loaves of bread (i.e.800g), supplied to us by independent bakeries, will be sold as per government regulations, i.e.5% below - 10% above or 760g to 880g.

THIS IS OUR PLEDGE
TO YOU,
THE CONSUMER.

PICK 'N PAY
BROOD BELEID

INHUISE BAKKERY - STANDAARD BRODE

Ons waarborg dat ons standaard brood (bv.800g)wat in ons bakkerye gebak word 'n minimum gebakte massa van 800g sal wees.

ONAFHANKLIKE BAKKERYE- STANDAARD BRODE

Ons waarborg dat standaard brood (bv. 800g) wat aan ons verskaf word deur onafhanklike bakkerye, sal verkoop word binne die neergelegde regulasies wat 'n variasie toelaat van tussen 760g tot 880g (minus 5% en plus 10%).

DIS ONS BELOFTE AAN U, DIE VERBRUIKER.

Pick 'n Pay

Supermarkets
Hypermarkets
Superstores

APPENDIX 7 (b)

Symptoms of INSULIN REACTIONS may be different with each person. It is important that he recognises and respond to his own first symptom, by eating or drinking something with SUGAR in it, then following that with some food.

What to do

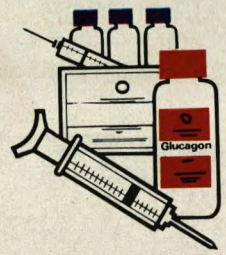
- Always treat a "hypo" with foods or beverages containing approximately 2-3 rounded teaspoons of sugar or honey
- Always take an extra carbohydrate portion food immediately after a "hypo" (Unless meal follows within 15 minutes).

Others must help

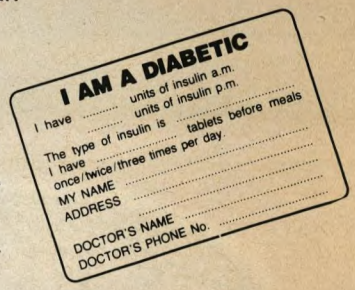
Sugar in some form should be kept readily available at home, i.e., plain sugar, sweets, syrup, honey etc. DIABETICS should always carry some.

Friends and co-workers of the DIABETIC should be told of the condition, explaining the signs and symptoms of reactions and what to do when they occur.

If advised by the doctor - the DIABETIC should keep a 'glucagon kit' ready for use at home. When a REACTION is so severe that sugar cannot be swallowed, GLUCAGON is administered by insulin syringe. A member of the household must know how to inject the GLUCAGON and to do so immediately if necessary.



Every DIABETIC person should carry some means of identification such as a wristband, necklace or wallet card so that those rendering emergency aid will be able to give prompt and correct treatment.



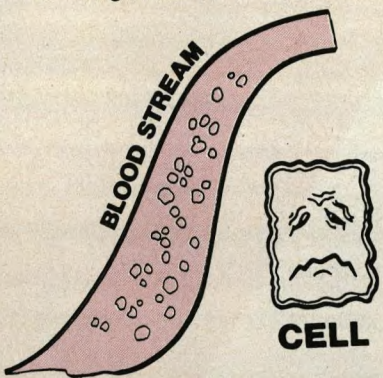
Nothing should be put into the mouth of an unconscious person.

Insulin role in Diabetes

INSULIN plays a very important role in the functions of the body.

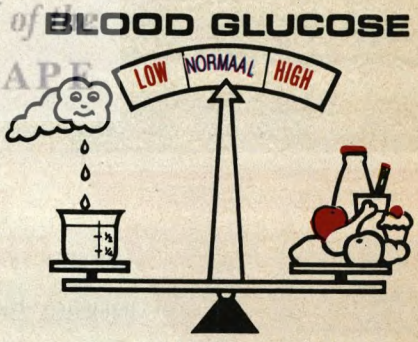
Just as a house is made up of bricks the body is made up of lots of tiny CELLS, which you can only see with a microscope. These cells enable us to do many different jobs - some make us think and some break down our food.

1 In order to do these things, THE CELLS NEED A FUEL CALLED GLUCOSE which is brought to them in the blood. Most of the GLUCOSE in the blood comes from the food we eat. But in order to use the GLUCOSE, the CELLS NEED INSULIN. INSULIN makes it possible for the GLUCOSE to leave the blood and get inside the CELLS.



2 Without INSULIN the CELLS cannot get their GLUCOSE and without this fuel the body cannot run smoothly. This is why Fred felt tired and listless, and began to lose weight.

3 In a normal everyday situation people will either skip breakfast altogether - or just have a small one. They may or may not have morning tea, and usually lunch is not a very substantial meal either - whereas the evening meal is generally the big feed-up.



4 In this case the right amount of insulin is released by the PANCREAS every time some food is eaten, and this is why the BLOOD GLUCOSE LEVEL REMAINS NORMAL AND PERFECT BALANCE IS MAINTAINED. This was the situation before Fred got DIABETES.

5 Now that he has DIABETES it's a very different story. The GLUCOSE built up in his blood to a much higher level than normal instead of being able to get inside the CELLS to do its proper work.

6 This is why a DIABETIC has to control his DIABETES - to try and KEEP HIS BLOOD GLUCOSE AS NEAR NORMAL AS POSIBLE

We would like to thank the S A Diabetes Association for providing us with the information to do this article. For more information, contact: ***SA Diabetes Assoc. Box 3943, Cape Town 8000. Telephone: (021)461-3715***

Hull Web Offset Jnb 1213/1

8.1 EXCERPTS FROM THE INTERVIEWS

8.1.1 PRE-INSTRUCTION INTERVIEWS

The pre-instruction interview was done with the EXPERIMENTAL GROUP 1 only. Each of the subjects had an interview dealing with some problem-solving activity which is similar to the one they would be dealing with at a later stage and which all control subjects were to take. The second interview was done after the EXPERIMENTAL GROUP 1 had direct cognitive instruction, deliberately listing each and every step and advantage of the instruction.

ANALYSIS OF INTERVIEWS OF EXPERIMENTAL GROUP 1

IMPULSIVITY AND A LACK OF SPATIAL AND TEMPORAL ORIENTATION SEEMS TO BE THE ORDER OF EVERY SUBJECT EXAMINED. WHERE NEED BE I SHALL HIGHLIGHT THIS IF EXTREME OR STATE THE CONTRARY. NOBODY UNDERLINED ANY PART OF THE WORK THEY WERE READING NOR DID THEY HIGHLIGHT ANYTHING THAT WAS IMPORTANT IN SOLVING THE PROBLEM. EVEN UPON REREADING NOT ONE GOT ROUND TO DOING IT; INSTEAD EACH SUBJECT READ THROUGH THE WHOLE PASSAGE OR SCANNED HASTILY FOR SPECIFIC INFORMATION

LA

Reading almost perfect English with correct pause and emphasis. Reflects on reading and makes an effort to understand what she is reading. Does not highlight any section of the work nor underlines. Approach to question is above that of the average pupil but the ability to express herself adequately and to organise her ideas seems to be lacking. Loses herself along a time scale. Graph turns out to be superficially correct. Integration of the two sources of information not adequate to bring about a 'perfect' graph. Had problem doing simple calculations without a calculator.

ZB

Reading fair, no emphasis or reflection, no underlining or highlighting of metarial. Treats the table of information in isolation of the given paragraph. Does not even bother to go through it before answering the first question. Says that she

knows that if there is a table there will be a graph later. Has no idea that the table provides valuable information to answer other question successfully. Frantic when she discovers that she did not bring along a calculator to work out the population size. Organizational structures very poor and the ability to express herself even worse.

ZD

A total disaster. Cannot read with appropriate emphasis and pauses. Level of psychological development seems ~ 6 yrs below actual chronological age. Asks at every step to seek recognition for what she is about to do. Temporal and spatial orientation totally in disarray. Admits that everything is being done for her at home by parents and that she never really makes decisions. She totally lacks the ability to think about anything. Does almost everything wrong, even the simple calculation whilst using a calculator ! She obviously was not nervous! FH Reading passable and pauses occasionally to absorb what she is reading. Does not underline or highlight. Tries the calculation without a calculator but then grabs it in desperation to complete. Too used to it! Although some organisation appears to be existing it is not enough to get through problem solving of this nature. Ability to express herself is reasonable although the conclusions arrived at are sometimes bizarre

BI

Was so completely disoriented, confused and flustered that not much was completed during this session. Subject seems to have a total lack of confidence in what he is doing; afraid to reveal 'the truth about himself'. [He has a very sweet, open-and-bold aura surrounding his being.] Could not calculate the population size without the use of a calculator WI Seems very nervous and admits to it. General reading ability above average in the group but deeper insight and comprehension seems lacking as the problem-solving activity continues. Becomes completely disoriented and displays a great deal of impulsivity when attempting the graph. A condition I would diagnose as resulting from nervousness in the situation. Although she laughs about it she cannot shake the nervous feeling. Approach to the other questions was of a fair standard, planned and occasionally integrating the two sources of information, although not at all times when necessary.

CK

Academically very studious person and very nervous at the interview although very 'casual' about being nervous. Attempts calculations without calculator and succceeds, but to save time uses the calc. on the next calculation. Reading very well and displays some insight into the problem but also much impulsivity with answering and later decides that the wrong approach was used or some information had been overlooked. Intergrates the two sources fairly well but admits that on some occasions where it would've helped to use the table she did not; says that she does not always know where to draw lines when looking for answers.

ML

A very disillusioned being. Has so little faith in herself that she gives up even before she has started. With some encouragement we progressed somewhat just to discover that she does not have the faintest idea of how to integrate the table of information with the passage. like some of the others she reserves the table for a graph which she assumes would appear somewhere along the line of questions.

WS

Very casual yet interested and excited about what is going to happen. [He was the first to come for the interview. Very soon he finds the recording apparatus fascinatingly outdated (It is mine!) I did not warn him beforehand, like I did with the others, that I was going to record the interview. He could have brought something more sophisticated along he reckons. Starting off reading in a very mediocre tone with little expressed emphasis he manages to get through the first few questions with little difficulty. He, however, gets stuck with the graph, going back in time and justifies his movement back in time. I could not believe that a person of his 'proven calibre' could or would ever come up with something like 'yes ! you can go back in time !' Many made terrible mistakes with choosing points along the axes, even choosing the correct axes, but this was the extreme. Most of the time was spent on discussing the spatial and temporal aspect of the set-up of the problem. Eventually we agreed that going back in time is notpossible. By this time our 30 min session was way over time but this little boy was an eager beaver for 'corrective measures'.

SS

Seems a very organised person as far as reading and reasoning is concerned. He plans his answers very well and is able to organise himself spatially. The temporal aspect of this problem is somewhat tricky if you do not take special care in orienting yourself so what he does is to grab a scale and work from there, initially wrong but is soon able to figure out a way to set the time straight. Has very few problems in answering q's correctly and documenting his thought clearly and logically.

8.1.2 POST-INSTRUCTION INTERVIEWS

LA

Seems quite at ease and starts off with a 'global glance' and then reads, underlining what she thinks is or would become important. Underlines the section in the instructions which indicates an integration of two sources of information. Underlines the key of each question as she proceeds to answer the questions. Also takes the time to label the organs represented by the sketches as the situation requires it. Although the answers provided were in most cases not strictly correct the organisation of her thought processes and way of expressing her ideas are very good. She makes full use of the short paragraph,

reading into it wherever possible and successfully integrates the sketches with the paragraph. She did not get very far though because she thrashed out her thoughts completely at every question.

ZB

Very calm and contented as she proceeds to read in her slow, unassuming,unindicative tone. I find it difficult to establish whether she understands anything that she is reading. Underlines some words in the paragraph, but I doubt if she knows why. Half of the NB info she neglects to underline. Now starts organising herself. Looks at the sketch and tries to identify the organs aloud. After carefully considering, she guesses an answer, contemplates on the second question and decides to proceed to the third as she does not want to waste time with something that could take 'forever' to figure out. Proceeds to 4 and 5 and then decides to reread info and q. Looks much more satisfied now and returns to q 3 where she left a space, knowing she would get back to it. She remembers a great deal of info related to the topic and works through all 7 ques in the set time, although not correctly answering all of them. She seems to be in command of the material and integrating the sketches well with the short paragraph. Answers well sorted out and thought through.

ZD

Jammmmmssss into the paper by reading in a boring tone without any emphasis, but goes through it again and underlines practically every part of the paragraph that may have a significant influence on any answer. Reads through the q's as well and underlines the core of each question. Does not pay much attention to the instructions given and resultantly ends up not doing everything that is required. Chooses and answer without substantiating why that choice. Where reasons are supplied it is totally out of context or in conflict with factual data. Rushes through and is very proud to have finished in less than the stipulated time, probably knowing that some subjects never got through the paper. Thinking does not seem to be well organised and in some cases (eg. 4,5,6) the information supplied does not directly answer the q's.

FH

Reads very well and tries very hard to concentrate and absorb what she is reading. Underlines when reading a second time. No UL in q's. Examines the sketches very carefully while answering the q. Has a bad time coping with a cold and copious secretions leaving the nostrils. It is obvious from the answer sheet that the command of the subject material is practically zero, but to organise zero knowledge into some form of answer takes courage. Q 1 - 6 have been attempted and the thoughts on the issue well documented.

BI

Reads through once, very slowly, and underlines NB info in paragraph. Positively identifies the area of examination and proceeds to answer the q's. No UL in q's. Approach to answering

q very direct and in some cases when he does not know an answer his explanation for not providing an answer is so good (valid erroneous thinking !) that I am tempted to credit his reasoning for arriving at an 'incorrect' conclusion. Recall of factual material not bad at all but does not complete all q's as the exposition of his logical reasoning tends to be fairly extensive Thoughts seem fairly well organised.

WI

Appears nervous. Says that she's not scared and does not know why she is nervous. Reads very well and UL as she emphasises certain parts of the paragraph. Does not bother with the instructions given and thus fails to subsantiate her answers until reminded to read everything. Reads each q carefully but does not UL in q. Successfully integrates the sketches with the paragraph, marking the sketch on one occasion. Now looks very nervous and scared that the answers which she's providing may all be incorrect - a feeling of hopelessness sets in. The answers provided are not as incorrect as they are incomplete and some off the point. A positive step at this stage is that she writes down the names of the various organs - one or two incorrect. In spite of all the doubt she attempted all the q's.

CK

Reads through the section thoroughly and boldly UL everything she may need later. Reads the instructions with the same intensity and UL and then proceeds to read through all the q's UL as she proceeds. Rushes along with some zest and draws some schematic representation of the food consumed by John. Labels most of the organs represented by the sketches. Her brilliant choice of answers amazes me as she does it with such haste, but the reasoning behind it perfect. She does not document these as she is in too much of a hurry. As long as I know what she thinks while solving the problem it's OK with her. She does not feel to write down everything. The answer to-4 and 7 'incorrect' . The factual info supplied holds, but does not suit the question. All others answered 'satisfactorily - very good' and all done in ~ 20 min ! That's all the time she would devote to the interview at this stage. Qualitatively she has done much more much better than any other subject who sat for the whole 30 min. Her systematic approach to the subject matter weighs heavily in her favor.

ML

Reads very lazily and seems somewhat lethargic about what confronts her on the information sheet. Underlines NB issues in paragraph and starts reading q and answering immediately. Discovers that she did not 'absorb' much of what she read she re-reads and looks at the sketches. Unable to identify many of the organs which makes answering more difficult. In the 20 min spent on the q's very little was achieved and it seems as if subject is turned off by subject matter not known. Although few q answered correctly subject seems to be able to integrate the info given and the sketches satisfactorily, but little planning and time taken to contemplate on an answer.

WS

Reads OK and UL NB info. Does not UL when reading q's. Approach to paper somewhat negative as the section 'has not been studied yet'. As he proceeds to read again he must be recalling more information as he seems to be lightening up somewhat. Documents some thoughts before proceeding to answer the q's. Writes down some q's for himself which he presumes would help him solve the problems - and they do ! Omits q 5 & 6 leaves space though, and continues with 7 on the right track but time's up. In spite of the negative start he pulled himself together very well and kept his thought process in control so that answers are fairly accurate and complete.

SS

Looks somewhat flustered as he scans over the paper and recognises some aspects. "I should approach the problem positively though and it should not be too difficult !" He examines the sketches and reads through the q's first to get an idea of what to look for when he reads the passage. Reads a sentence aloud, then silently and UL during latter phase. Identifies all organs and criticises my 'weird' sketch representing the pancreas. "It could only be the pancreas as I've identified everything else," he says. Proceeds with elaborate analysis of process involved in nutrition and explains why he chooses the specific answer for q 1. Again a detailed exposition of the reasoning for q 2 & 3, very well documented and in accordance with biological facts. Although he only attempted three q he maintains that speed and haste at this stage is not NB as he is checking whether is thought processes are what they 'are supposed to be !" He is able, at all times, to use the sketches successfully in his problem-solving activity and integrate it with the information supplied. He maintains that it does not pay to be impulsive. Instead he prefers to plan his work very well and during exams he exercises much speed. He has documented that "Speed is intelligent haste"

8.2 INITIAL QUESTIONNAIRE

QUESTIONNAIRE : MATRIC BIOLOGY Class:

NB* If you need more than the provided space for an answer please write the number of the question at the back of this page and continue the answer there.

1. How much water do you consume per day?

_____

2. How much water do you think you should consume daily?

_____

3. In which form(s) do you consume water?

_____

4. What do you think happens to the water you consume?

_____

_____

5. How much salt(s) do you consume daily?

_____

6. What happens to the salt(s) you consume daily?

_____

_____

7. How much sugar/carbohydrate do you consume daily?

_____

8. In what form do you consume carbohydrates/sugars?

_____

_____

9. What do you think happens to all the carbohydrates that you consume?

10. Mention the phases of nutrition and briefly define each phase.

11. Distinguish between secretion and excretion.

8.3 PROBLEM FOR INITIAL INTERVIEWS

AND

FOR THE DELIBERATE INSTRUCTION PROGRAM

ADAPTED COGNITVE OPERATIONS TEST

1. Read the following passage and answer the questions based on it.

A beetle population was thriving in an area next to a river. An investigator once captured 35 beetles, marked them with a white dot and released them again. Three days later he captured 40 beetles and discovered that 7 had white dots. Three months later the area was flooded after heavy rains. As soon as the area was clear enough for inspection he captured 20 beetles, marked them with red dots and released them again. Three days later he captured 24 beetles, 6 of which had red dots. He checked the area periodically after the floods and calculated the population size every four months. The following was the data obtained:

time in months after floods:	4	8	12	16	20	24	28	32	36	40
Number of Individuals	85	90	100	170	260	300	340	280	302	305

1.1 Determine the size of the population before the floods. (5)

1.2 Mention FOUR criteria which must hold (be true) if the results of this method is to be trusted. (4)

1.3 What is the effect of the flood on the population size? (2)

1.4 Is the flood a density dependent or density independent factor influencing the population size? Explain. (4)

1.5 Use the given data to draw a graph of population growth since the start of the investigation,i.e. start before the floods occurred. (6)

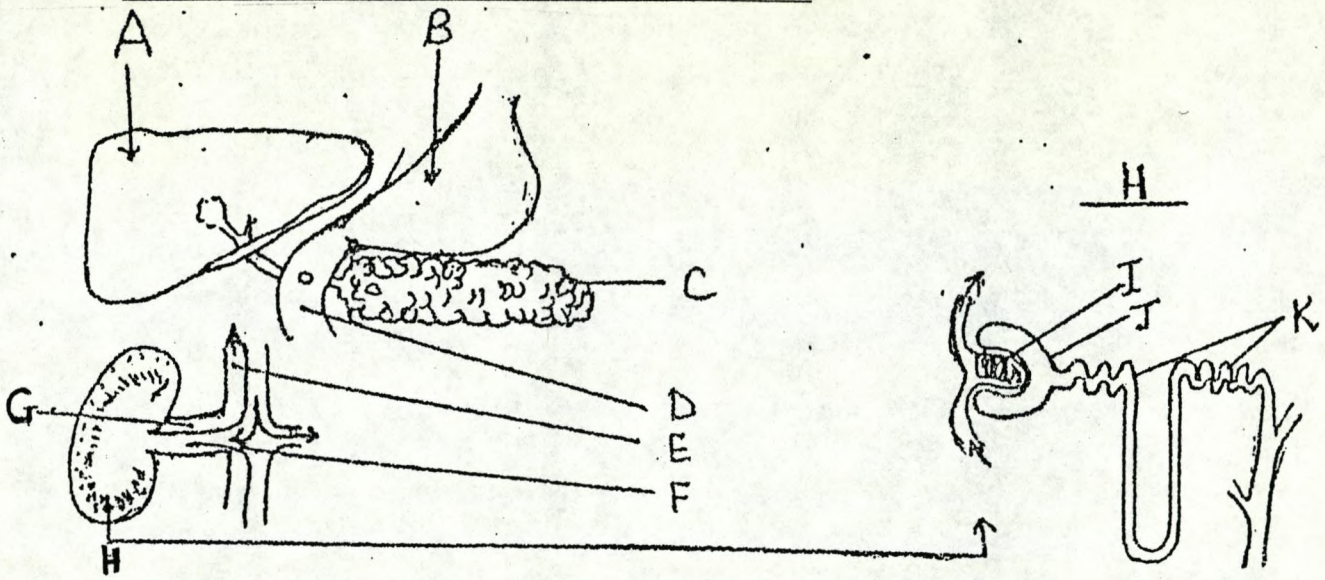
1.6 Explain the slow growth immediately after the floods. (6)

1.7 Why is there such a sharp drop in numbers at 32 months after the floods? (6)

1.8 Are the factors causing this drop density dependent or density independent? Explain. (2)

1.9 How many beetles can be housed at carrying capacity of the environment? (2)

8.4 PROBLEM USED IN IDENTIFICATION OF SKILLS AND IN FINAL INTERVIEWS OF ALL GROUPS



THE ABOVE SKETCHES REPRESENT SIMPLIFIED DIAGRAMS OF ORGANS OF LAZY, GLUTTONOUS JOHN. About four hours ago he had eaten an enormous chip roll and a cup of coffee with an abundance of sugar. He is still resting after his meal.

Use the sketches and information above to answer the questions below. Substantiate each answer with your logical reasoning.

1. Which part of his body represented above would be most active in digestion of this particular meal?
2. What is the response of D to the contents of B entering it?
3. What is the response of C after complete absorption of the 'chip roll' and coffee?
4. Which organ would the absorbed 'chip roll' reach first?
5. How would the concentration of the absorbed 'chip roll' differ in the vessels marked F and G?
6. How does the concentration of the absorbed 'chip roll' differ in J and K?
7. Name the metabolic waste product formed in A. How does the concentration of this product differ in vessels marked F and G?

8.5 FINAL TEST QUESTIONNAIRE

FINAL COGNITIVE OPERATIONS TEST

NAME:_____

AGE:_____

STD:_____

ANSWER THE FOLLOWING AS COMPLETELY AS POSSIBLE. WRITE DOWN **ALL** YOUR THOUGHTS WHILE YOU ARE WORKING THROUGH THIS WORK SHEET. ANSWER ON SHEETS PROVIDED. PLEASE DO NOT TEAR OFF ANY PART OF YOUR ANSWER SHEER. DO NOT USE TIPP-EX OR ANY EQUIVALENT. RULE A LINE THROUGH 'CANCELLED' INFORMATION, BUT LEAVE LEGIBLE.

THANK YOU VERY MUCH FOR YOUR COOPERATION.

1. Describe what you understand by the term 'homeostasis'.
2. Explain why the pancreas can be regarded as both endocrine and exocrine gland.
3. Distinguish between absorption and reabsorption by using suitable examples.
4. Use the following terms logically and correctly in a paragraph which would explain some aspect(s) of homeostasis: (a) homeothermy/poikilothermy ; (b) secretion/excretion ; (c) hypoglycaemia/hyperglycaemia ;(d) digestion - absorption -assimilation - reabsorption ; (e) negative feedback

8.6 FEEDBACK FORM SUPPLIED TO PIONEER GROUP

TO ALL SUBJECTS INTERVIEWED IN 1989

Please fill out this information list as truthfully and completely
as possible. All information supplied will enjoy the strictest confidence but generalisations may be drawn from this information to
assist in the investigation you are part of.

Name:_____

Number of Interviews: _____

Current Full Time Activity

Employment:Company:_____

Position:_____

Field of Study:Institution:_____

Course:_____

Please answer the questions below on the attached sheets of paper.
If you need any more space you may use any other ruled sheet to complete your comments.

1. To what extent did the interview(s) influence your final results in matric?

2. Which skills or ideas or both did you derive from your interview(s)?

3. How are you currently applying the skills or ideas mentioned above?

4. What would you recommend to make such an interview more successful?

5. Any other comments.

Thank you for you cooperation

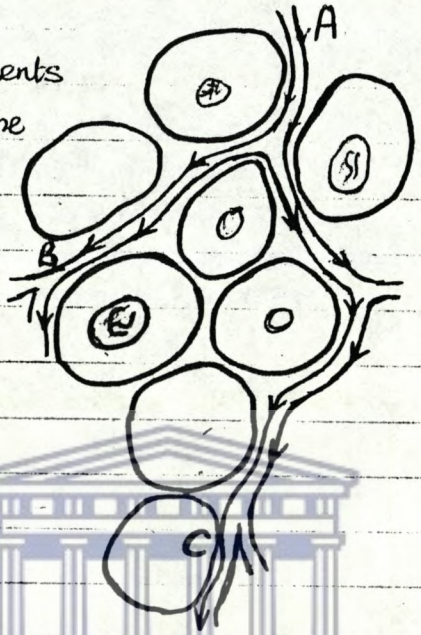
BIOLOGY COGNITIVE SKILLS INVENTORY

8.7 Problem Used with Braintree High pupils.

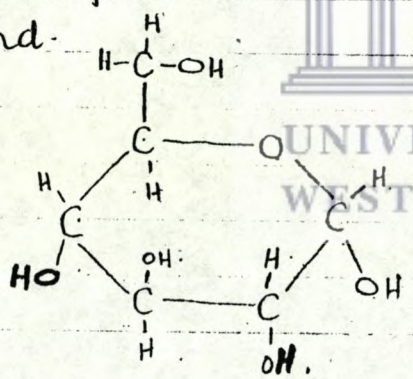
Use the information below to answer the questions.

You have consumed a large portion of French fries and a cup of coffee with lots of sugar about four hours ago. Since then you have been moving to your classes and had a wild time in one of your classes as the teacher is absent.

The adjacent sketch represents a number of cells and the blood vessels servicing it. The direction of blood flow is indicated by arrows.



D below represents a molecule of a certain compound.



Questions based on the information

1. Did you consume this compound? Explain
2. If you had consumed any other compound(s), name it and state how it differs from compound D.
3. Would diffusion/osmosis of D occur at points A, B + C? If so, explain the direction and rate of movement.
4. Would an equilibrium ever be established? Explain.
5. What would happen if too much of 'D' would enter the bloodstream in a very short time?
6. What would happen if 'D' is lacking in the blood for an extended period of time?

APPENDIX 8.8

Extract from: WHIMBEY, A. and LOCHHEAD, J.
Problem solving and Comprehension - Fourth Ed. 1986
pp. 18 - 20

CHECKLIST OF ERRORS IN PROBLEM SOLVING

The following is a checklist of sources and types of errors in problem solving. Some of the items overlap, referring to different aspects of the same fault in working problems, but this overlap is unavoidable because various factors that underlie problem-solving skill are interrelated. Read the checklist aloud, discussing any items that are unclear. Then, as you solve problems, be careful not to make these errors. If you recognize some particular error to which you are especially prone, take extra pains to guard against it. Also, when you are listening to another student solve a problem, watch his approach for errors of the type listed below.

Inaccuracy in Reading

1. Student read the material without concentrating strongly on the meaning. He(she) was not careful about whether he understood it fully. He read sections without realizing that his understanding was vague. He did not constantly ask himself: "Do I understand that completely?" This showed up in his errors later.

2. Student read the material too rapidly, at the expense of full comprehension.

3. Student missed one or more words (or misread one or more words) because the material was not read carefully enough.

4. Student missed one or lost one or more facts or ideas because the material was not read carefully enough.

5. Student did not spend enough time rereading a difficult section to clarify its meaning completely.

Inaccuracy in Thinking

6. Student did not constantly place a high premium on accuracy - He did not place accuracy above all other considerations such as speed or ease of obtaining an answer.

7. Student was not sufficiently careful in performing some operations (such as counting letters) or observing some fact (such as which of several figures is the tallest).

8. Student was not consistent in the way he interpreted words or performed operations.

9. Student was uncertain about the correctness of some answer or conclusion, but did not check it.

10. Student was uncertain about whether a formula or procedure he used to solve the problem was really appropriate, but did not check it.

11. Student worked too rapidly, which produced errors.

12. Student was inaccurate in visualizing a description or a relationship described in the text.

13. Student drew a conclusion in the middle of the problem without sufficient thought.

Weakness in Problem Analysis; Inactiveness

14. Student didn not break a complex problem into parts. He did not begin with a part of the problem that he could handle in order to get a foothold. He did not proceed from one small step to the next small step, being extremely accurate with each one. He did not use the parts of the material he could understand to help him figure out the more difficult parts. He did not clarify his thoughts on the parts he did understand and then work from there.

15. Student did not draw upon prior knowledge and experience in trying to make sense of ideas which were unclear. He did not try to relate the written text to real, concrete events in making the meaning clear and understandable.

16. Student skipped unfamiliar words or phrases, or was satisfied with only a vague understanding of them, rather than trying to obtain a good understanding from the context and the remainder of the material.

17. Student did not translate an unclear word or phrase into his own words.

18. Student did not use the dictionary when necessary.

19. Student did not actively construct (mentally or on paper) a representation of ideas described in the text, where such a representation could have helped in understanding the material

20. Student did not evaluate a solution or interpretation in terms of its reasonableness, i.e. in terms of his prior knowledge about the topic

Lack of Perseverance

21. Student made little attempt to solve the problem through reasoning because he lacked confidence in his ability to deal with this type of problem. He took the attitude that reasoning would not work with this problem. He felt confused by the problem, so did not start systematically by clarifying the portions of the problem which were readily understandable, and then attempting to work from there.

22. Student chose an answer based on only a superficial consideration of the problem - on an impression or feeling about what might be correct. Student made only a superficial attempt to reason the problem then guessed an answer.

23. Student solved the problem in a mechanical manner, without very much thought.

24. Student reasoned the problem way through, then gave up and jumped to a conclusion.

Failure to Think Aloud

The items above apply to all academic problem solving. The last item refers specifically to the procedure used in this course.

25. Student did not vocalize his thinking in sufficient detail as he worked through the problem. At places he stopped and thought without vocalizing his thoughts. He performed a numerical computation or drew a conclusion without vocalizing or explaining the steps he took.

APPENDIX 8.9 A (i)

CHERAN KATTS E-G 1

1. THE REGULATION OF A CONSTANT INTERNAL ENVIROMENT SO THAT EVERYTHING CAN FUNCTION TOGETHER HARMONIOUSLY AND IN A SYSTEMATIC WAY.

2. THE PANCREAS RELEASES TWO HORMONES AND A SUBSTAINCE CALLED PACREATIC JUICE. THE PANCREAS RELEASES THE HORMONES, INSULIN & ~~[illegible]~~ GLYCOGEN.) DIRECTLY INTO THE BLOOD STREAM THEREFORE IT CAN BE REGARDED AS AN ENDOCRINE GLAND. THE PANCREAS ALSO ~~RELEASES~~ THE PANCREATIC JUICE VIA A DUCT CALLED THE PANCREATIC DUCT INTO THE DUODENUM. THEREFORE ALSO AN EXOCRINE GLAND.

3. ABSORBTION IS THE PROCESS WHEREBY DISSOLVED DIGESTED SUBSTANCES CAN BE TAKEN INTO THE ~~BLOOD SYSTEM~~ MUCOUS MEMBRANE OR ~~EPI~~ EPITHELIAL LAYER.
REABSORPTION IS THE PROCESS WHEREBY DISSOLVED DIGESTED ABSORBED SUBSTANCES ARE TAKEN IN AGAIN (REABSORBED) INTO THE BLOOD STREAM.

Y THOUGHTS:
MISS FRYDIE BRENT IS LAUGHING AT WHAT I WROTE. HE IS NOT DOING HIS WORK AND HE IS NOT CONCENTRATING

APPENDIX 8.9A (ii)

TALKING TO MORNÉ. MORNÉ ASKED ME STUPID QUESTIONS I.E. HOW OLD IS MISS FRYDIE?
BROKE MY CONCENTRATION WILL HAVE TO START THINKING AGAIN..

HOMIOTERMY ARE WARM BLOOD ANIMALS AND POIKILOTHERMX ARE COLD BLOODED ANIMALS. THE PROCESS WHEREBY THESE ANIMALS MAINTAIN THEIR BODY TEMPERATURES AT A CONSTANT LEVEL. SO THAT THE ANIMALS WILL THEN BE ABLE TO MAINTAIN A CONSTANT ENVIROMENT.
SECRETION IS THE RELEASE OF SUBSTANCES WITHIN THE BODY INTO THE BLOOD STREAM.
EXCRETION IS THE RELEASE OF WASTE PRODUCTS TO THE EXTERIOR.
THE REMOVAL OF WASTES FROM THE BODY.
HYPOGLYCAEMIA REFERS TO THE BLOOD SUGAR LEVEL WHEN IT IS LOW.
HYPERGLYCAEMIA REFERS TO THE BLOOD SUGAR LEVEL WHEN IT IS HIGH. ABOVE THE NORMAL LEVEL.
DIGESTION IS THE BREAKING DOWN OF INSOLUBLE SUBSTANCES INTHE BODY INTO SOLUBLE DIGESTIBLE SUBSTANCES IN THE BODY.
ABSORPTION IS THE TAKING IN OF THE DIGESTED SUBSTANCES SO THAT IN COULD BE UTILIZED IN THE BODY.

ASSIMILATION REFERS TO THE DISTRIBUTION OF NEEDED SUBSTANCES in the BODY WHICH HAVE BEEN ABSORBED.

REABSORPTION IS THE ABSORPTION OF SUBSTANCES WHICH HAVE ALREADY BEEN ABSORBED.

NEGATIVE FEEDBACK IS A MECHANISM WHEREBY THE HOMEOSTATIC LEVEL WILL BEABLE TO BE MAINTAINED BY THE RELEASE OF MORE HORMONES OR LESS HORMONES DEPENDING ON THE NEEDED AMOUNT THAT THE BODY REQUIRES TO BRING IT BACK TO NORMAL.

8. EG'S OF ABSORPTION & REABSORPTION CAN BE FOUND IN THE ABSORPTION OF FOOD INTO THE SMALL INTESTION AND THE REABSORPTION OF H_2O FROM THE LARGE INTESTINE.

APPENDIX 8.9 B (i)

FAYRANA SHABODIEN E-G 2 STD. 10.E

1) THE MAINTENANCE OF THE BODIES FLUID AT A CONSTANT LEVEL

2) THE PANCREAS IS EXO ~~END~~OCRINE GLANDS BECAUSE IT SECRETES PANCREATIC VIA THE PANCREATIC DUCT. TO TARGET ORGANS. ITS IS AN END ~~E~~XOCRINE GLAND BECAUSE IT SECRETES SUBSTANCES ALSO DIRECTLY INTO THE BLOODSTREAM INSULIN & GLUCAGON.

3) ABSORPTION WHEN SUBSTANCES ABSORBED SO THAT THE BODY CAN PERFORM SPECIFIC FUNCTIONS AND REABSORPTION IS WHEN THE BODY REABSORBS NUTRIENTS FROM THE BLOODSTREAM IF NEEDED EG KIDNEY

4) To keep the bodies temperature constant poikilothermy are cold-blooded animals and homeothermic are termed so as warm-blooded animals. During summer winter homeothermic animals secreted H_2O by means of perspiration and during this process energy is loss causing the body to feel listless and lax. Thus blood pressure pressure is much higher on warmer days than on colder days. On colder days the body does not perspire easily and thus excretes more urine The body is more active on a a cold day than on a warm day. The sugar level on a hot day will be lower than

compared to coldx day. Hyperglycaemia is when the body has an excess of glucose while hypoglycaemici is when the body needs more glucose. So that a cold more energy will be needed. Digestion will take place quicker on a cold day than on a hot day because the body is metabolism is much more active. Thus the body will absorbt nutrients needed. Thus when sugar level to high (hyperglycaemia) the blood sends messanger to the brain and the hormone insulin will be secreted into the bloodstream when sugar level is back to normal negative feedback will occur which will inhibit the secretion of of insulin and conversion of glucose into glucagon. But this will not take immediately a little more insulin will be excreted. In poikilothermic animals homeostatic control will be reversed.

APPENDIX 8.9 C

Shannaz B

CONTROL GROUP.

The maintenance of a constant environment. (I think) It involves a group of systems which function together as a whole. If one does not fit in its place, it changes the whole idea (maintaining).

2. Endocrine is ductless glands and exocrine glands with are ~~is~~ ducts.

3 Absorption is when food etc with all its nutrients. is taken into the system (body) Reabsorption involves kidneys.

This is a stupid test to hand out at this time of the day. The weather does not allow for me to even think further than getting home.

- homeothermy is warm blooded
- poikilothermy is cold blooded
- secretion is when something is inside the body
- Excretion is waste given off by by body to outside
- hyperglycaemia is something big, huge
- hypoglycaemia is in large numbers
- Digestion is break down of food inside body. (Yusuf stop laughing) Fill in your form.
- absorption - proven above
- assimilation → transported all over body
- reabsorption - already answered
- negative feedback : mechanism for stabilising, (~~eg : heart~~) to do with chemical co-ordination. Now I'm tired! My stomach is sounds like a volcano erupting

REFERENCE LIST

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