DEPARTMENT OF SCIENCE EDUCATION

Diploma-in-Education

Curriculum Studies Options

[Biology/Chemistry/Physics]

Handbook

Theme 1

Understanding My Pupils

INSTITUTE OF EDUCATION

CSO/THEME 1

CONTENTS

FOREWORD

It gives me great pleasure to write the forward to this series of theme books for your CSO Course. The topics presented in these theme books come in no small way from the effort of the contributors. I wish to express my thanks to them and in particular to the coordinator taking charge of each of these theme books.

The topics have been grouped thematically with the interrelationships between them shown in Figure 1 on the next page. These themes are:

Theme 1 - Understanding My Students

Theme 2 - Exploring Various Approaches

Theme 3 - Managing the Science Environment

Theme 4 - Evaluation and Feedback

Theme 5 - Curriculum Considerations

The themes have been selected to emphasize your professional development as well as your academic development as a subject specialist. Themes 1, 2 and 4 emphasize the professional development aspect of your training, while the subject matter of science is taken care of through Themes 3 and 5. It must be understood, however, that subject matter and methods cannot be dissociated from one another. Rather, subject matter can be expected to be weaved in as exemplars of the methods covered.

I hope you will find it interesting, reading through the material we have carefully prepared for the course.

TOH KOK AUN
Head/Department of Science Education

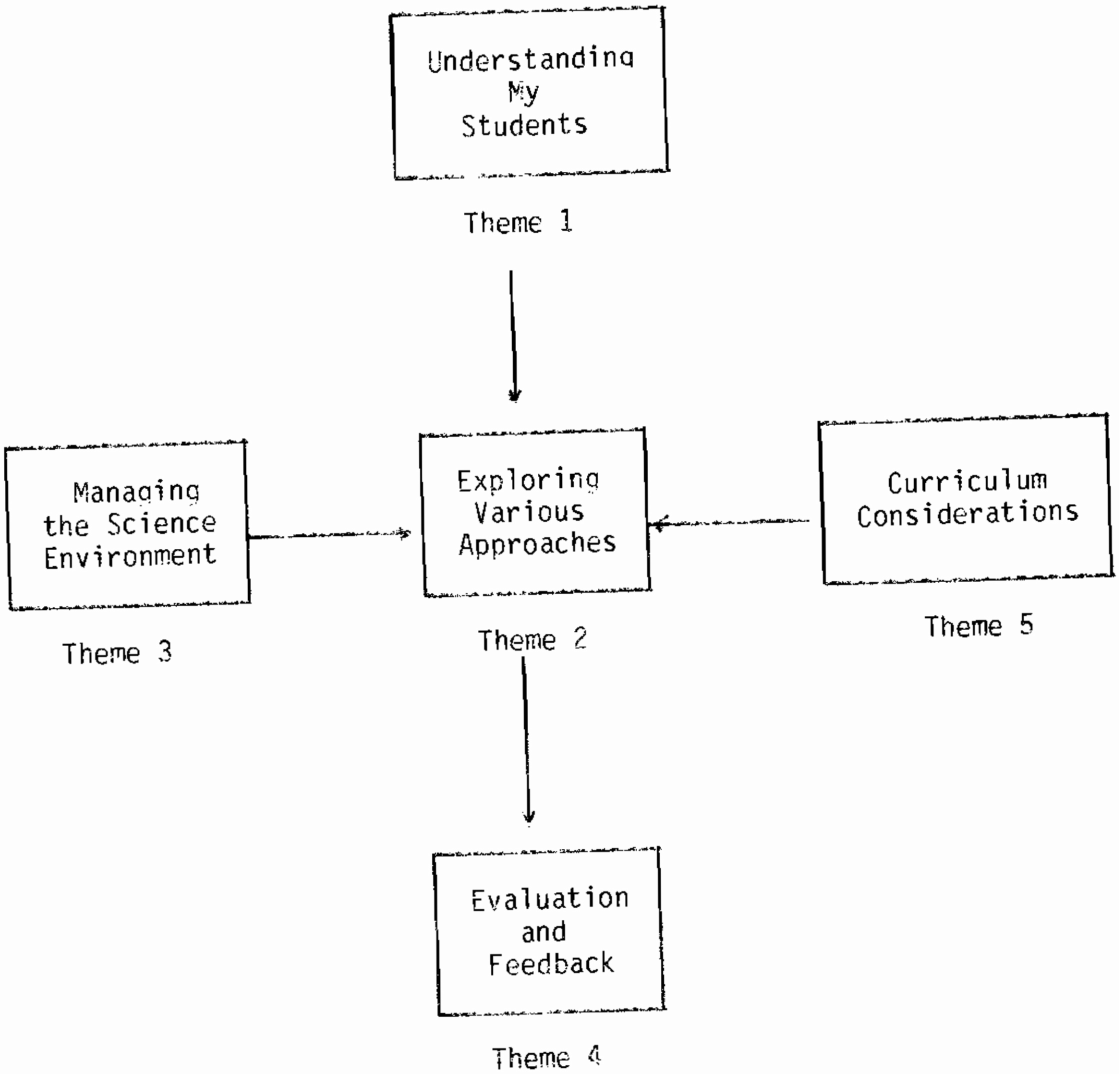


Figure 1 Overview of Your CSO Course

INTRODUCTION

This Theme 1 handbook entitled "Understanding My Students" focuses on the client. Under this theme there are six topics:

Topic 1 : Individual Differences and Strategies to Deal With Different Ability Groups with Particular Reference to Slow Learners

Topic 2 : How Concepts are Formed

Topic 3 : Examining the Way Students Think and Ways of Finding Out What is Understood

Topic 4 : Planning for Science Instruction with Objectives in Mind

Topic 5 : On Classroom Control, Affective Development and the Science Teacher

Topic 6 : Fostering a Better Teacher-Student Interaction during Science Lessons

The quality of learning that takes place should be the prime concern of every teacher. If the strategy in manipulating content and materials does not match the ability and interest of the students, the teacher is not creating the best environment for learning to occur. Since the central focus of all teaching is the learner, any strategy planned for the teaching of science either in the classroom or the laboratory should thus take student's ability and interest into account. As a result, understanding the students well is fundamental to success in teaching.

In nature, two exactly identical things are unlikely to exist. Hence, we have to accept the existence of individual differences among students. They are different not just because of being endowed differently, but their ways of thinking are tempered as well by being exposed to different environment, background and experiences. The process of streaming can never ensure a complete elimination of all their differences. The first topic therefore appropriately exposes you to these individual differences. A teacher should not expect homogeniety in a class of 40 students despite streaming. As such, the teaching approaches and materials used should allow for greater flexibility in order to cater for a range of needs.

"How Science Concepts are Formed" will be the basis for the second topic under the Theme : "Understanding My Students". This will take into account, how students acquire science concepts and how students' prior knowledge affects the learning of science concepts. The topic also rightfully covers how, as a classroom teacher, you can find out whether the concepts you have taught have been mastered.

It is important for practising teachers to devise ways of finding out what is understood by students. A teacher may be teaching something but what is internalised by 40 students could be 40 different variations. In principle, listening to what students say, reading through what students write, and observing how students perform skills are the essential means for gathering information about students' understanding. This gathering of information provides invaluable feedback to the teacher of what is understood. Then through the careful analysis of this feedback we can try to learn why students think the way they do. All this will be tackled in the third topic entitled 'Examining the Way Students Think and Ways of Finding Out What is Understood'.

Before presenting a lesson, a teacher should always ask herself questions like: "Why teach?", "What to teach?", and "How to teach?". In planning for science lessons, there should be an attempt to create a situation where the student actively confronts new concepts or skills being taught. The aims of a lesson should logically determine the teaching method and the content. Thus the fourth topic "Planning for Science Instruction with Objectives in Mind" will deal with useful guidelines for planning science lessons, provide some tips for writing performance objectives and include good examples of science lesson plans for your reference.

The role and responsibilities of the teacher have expanded tremendously. As a science teacher, we should help our students not only in learning facts, understanding them, developing cognitive and practical skills, but also in developing their attitudes and values; that is affective development. The fifth topic will thus touch on classroom control, affective development and the Science teacher.

The teacher and her students are the most important elements in the teaching and learning process. In recognition of the importance of these elements it is imperative for the teacher to be aware of the mechanics involved in fostering a better teacher-student interaction during her science lessons. Thus the sixth topic attempts to examine different teaching styles and their consequent effect on students and their learning.

I wish to thank Dr Goh Ngoh Khang who was the coordinator of the first edition (1985) of this handbook. The credit for part of this introduction goes to him. I also wish to thank Miss Kasmah binte Kassim and Miss Ida de Almeida, who have been extremely patient in the typing of the many corrections of the typescript of this handbook. I hope you will find the contents of this handbook useful and rewarding.

DR CHIA LIAN SAI
Coordinator/Theme 1 Handbook

July 1986

CSO/THEME 1

TOPIC 1 **INDIVIDUAL DIFFERENCES AND STRATEGIES TO DEAL WITH DIFFERENT ABILITY GROUPS WITH PARTICULAR REFERENCE TO SLOW LEARNERS**

Toh Kok Aun

INTRODUCTION

School Enrolment for 1984 in Thousands		
Primary	:	288.5
Secondary	:	185.8
Tertiary	:	32.8

If these figures are intended to tell us something, the following are some of the conclusions that can be drawn.

* The attrition rates are high.
* Only a small proportion (approx. 6.5%) are able to attain tertiary education.
* We are not all born equal.

Indeed, from the word "go", we are already endowed differently. The genetic inheritance with which each one of us is brought into this world, already predetermines in some way our future. The chances of two intellectual parents having a bright off-spring is high. But the concept of regression towards the mean also means this is not necessarily so.

The external influences of the environment will, in no small way, operate upon what has been inherited. Research has shown that the following are some of the environmental factors that will have a bearing towards individual differences:

° nutrition,

° education,

° language/speech,

° interaction with family and society,

° experience of the inanimate world,

° social class.

The outcomes will be differences in

- intelligence,
- personality,
- physical stature,
- motor skills.

In Singapore, parents are only too aware of the importance of adequate exposure of their children to a variety of learning situations. Barring a few isolated cases of latch-key kids, by and large, the majority of parents are conscious of not depriving their children of an early start in life. The importance of the latter is substantiated by the research work of Professor Jack Tizard of the University of London. According to him the intelligence of an individual is settled largely by the age of five; and the most important influence that determines the development of the child are the conditions under which the child is brought up. The key line here is that while nature is in no small way important in the development of a child, what is even more important is the environment with which the child is nurtured.

IQ SCORES

Let me digress a little to give you some ideas of how IQ is measured. Modern intelligence testing began with the work of Alfred Binet in France late in the 19th century. Binet's procedures were revised and augmented by Terman and his associates at Standford University, hence the name Stanford-Binet for the test that introduced the term 'IQ' to education and psychology. This term which stands for 'Intelligence Quotient' is no longer correct, since the quotient method is no longer used.

The raw scores of the Stanford-Binet are in terms of the mental age, such as 80 months (i.e. 6 years and 8 months). A child who achieves this score, whatever his actual chronological age, has done as well at the various tasks as children in a standardized sample who were actually 80 months of age. If a child has a mental age of 80 months and actually is 80 months old, then, by definition, he is of "average" intelligence. If a child's mental-age score is 80 and he is only, say, 74 months of age chronologically, then he would be above average in intelligence.

But as always when comparing a person's score with an average, we have to ask how much above average. Significantly? Mildly? Moderately? Incredibly? And how do we compare the performance of different chronological and mental ages? Using the old "ratio IQ" method (due to Terman), the mental age was divided by the chronological age. Thus a child who achieved a score of 80 and was 74 months old would have a ratio IQ of 80/74 or 1.08. This number (i.e. 1.08) was multiplied by 100 purely for convenience, resulting in an Intelligence Quotient of 108 in this example.

In this system a child of 6 years old who achieved a mental age of 9 has a ratio IQ given by:

$$\text{Ratio IQ} = \frac{\text{Mental Age}}{\text{Chronological Age}} \times 100$$

$$= \frac{9}{6} \times 100 = 150$$

The ratio IQ method worked well for almost half a century, but it has a few flaws:

* intelligence does develop with age as the scoring system presupposes, but not at a uniform rate from year to year;

* ratio IQ's at different ages are not exactly comparable;

* virtually all basic intelligence skills are developed by the early or middle teens, beyond that time the mental age concept is not usable; a 35 year old and a 24 year old of equal capabilities would have the same mental age score, so the ratio IQ would not be practical.

This does not mean that ratio IQ's are "invalid". In fact, an IQ computed on the old basis represents approximately the same level of intelligence as IQ's computed on the new (post-1960) basis, called the <u>deviation IQ method</u>. It was in 1960 that the Stanford-Binet was <u>revised and updated</u>; and the scoring system was changed from the ratio IQ method to the deviation IQ method. In the new method, the average IQ at any age is still 100. The scores are normally distributed with a mean of 100 and a standard deviation of 16. Since we know the mean IQ and the standard deviation, we can transform any individual's Stanford-Binet IQ into a z-score and then find the percentile equivalent.

THE SINGAPORE SCENARIO

In the Singapore context, where people is an all important resource, the attrition figures mentioned in the introduction are frightening. To allow for open competition between the less able and the more able ones is meaningless. The chronological age of a 14 year old child who is mentally equivalent to that of a 12 year old has a 2 year gap and would be frustrated if left unattended to with other 14 year olds.

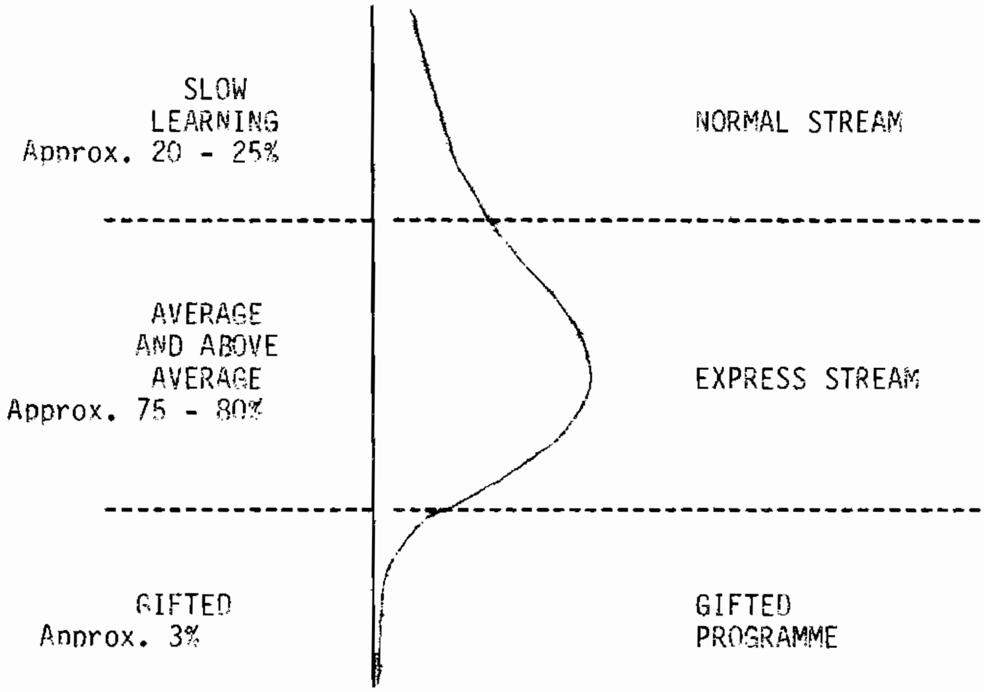
Possible Quantitative Difference in Intelligence for the Less-Able Child	
Chronological Age	Mental Age
6 years	5 years
10 years	8 - 9 years
14 years	12 years

Variation in abilities in any population might be seen as a plea for streaming in schools and a different curriculum for different ability groups. It is pointless pitching everyone through the same curriculum at the same pace. The less able ones would merely drift along with considerable failure rate.

At the other end of the scale there is the fast learning group and the gifted. Lumping everyone together be they slow-learning or gifted would mean that the gifted would find:

* absence of challenge in the work covered,
* their progress impeded, since the teacher has to slow down for the sake of the rest of the class.

Out of concern for wanting to provide a curriculum that brings out the best in every child and avoidance of disadvantaging any group, the educational system in Singapore allows for streaming at different stages of the path of a student. The top 3%, or "intellectual cream" are picked for a 'gifted programme', while the slower-learning 20-25% of the population are streamed into a Normal Stream (see diagram on next page). The bulk of the average and above-average students are grouped into the Express Stream.



IMPLICATIONS FOR SCIENCE TEACHING

What are the implications of all these for science teaching? Of the cognitive subjects in the school curriculum, English, Mathematics and Science (or commonly abbreviated as EMS) have always been given greater emphasis. Of these three subjects, English and Mathematics are taught from Primary One, while Science is only taught from Primary Three. The rationale behind this has been fairly well accepted. For one, there is a need not to over-burden the curriculum. For another, it was felt more urgent for children in Primary One and Two to gain a strong foundation in language and numerical skills - hence the emphasis on English and Mathematics and the deferment of Science until Primary Three.

To give you some idea of the standard of English let me give you an example of an essay written by a Secondary Four girl. The title of the essay is, 'What I hate most about the opposite sex'. It is reproduced faithfully with all the incorrect spelling to give you some idea of the appalling situation in some cases.

SAMPLE OF STUDENT'S WORK

What I hate most about the opposite sex

In Singapore, there are many feminine and masculine. Some of this two sexes, if they have just know each other, they would like to meet each other and by telephoning. In some theatre, park or any where, we can see boys and girls whose age was under eighteen, hold hand by hand. This is a very bad examples of both sexes.

As I was one of the feminine, I have the opinion to hate the masculine. Aspectually those who was proud act like they were a very brave and clever person. Masculine with long hairs and the clothes were unbotton, lazy and smoking is also the one I also dislike. We can see some of the masculine also does not like to work, they just like to wondering around, smoking and disturbing girls.

Sometimes in school, the school gate has many who look like gansters, is waiting near the gate to wait feminine students and shouting at them. Nowadays, most masculine made their hair in the centre parking, and they thought that they were look more handsome. If they meet you, and see you beautiful, they were try to contact their friend who know you, and introduce you to them. If you have telephone, they were keep on telephoning you. This is why I hate the masculine.

- End of Student's Work -

What are the implications of this for you as a Science teacher? Reading carefully through the essay you would be able to conclude that the girl has a fairly good vocabulary and has made attempts to use them. Sad to say, however, there seems to be inadequate exposure to the language. This particular girl, in all probability, do not read, listen and speak the language sufficiently - hence the errors in the essay. Lack of language skills will make it all that much harder for the science teacher to teach the subject. It would be so much harder for the student to express what he/she observes and what the inference is.

This aside, what should be the focus of science in the science curriculum of our schools? What variation in the science curriculum should be allowed for when dealing with different ability groups. As a general rule it is necessary to provide the able ones with a good education in science to provide for possible careers in science when they grow up. At the same time the less able ones, who are unlikely to specialise in a science area, the aims should be somewhat different. Some of these aims are:

* to relate science to daily experience and to the environment;
* to develop self-confidence and esteem through successful experience;
* to develop skills of observation, thinking and judgement;
* to use science as a means of providing education for leisure;

* to develop students' self-knowledge;

* to develop an awareness of science in society;

* to develop a basic understanding of scientific ideas.

Distilling from all these, it is therefore possible to conclude that:

> For the average plus, the emphasis should be to provide them with an education in science. Opposed to this, any science taught to the slow learners should be one which provides education through science.

In fact an abler student can be expected to generalise (not without danger) from a few examples and apply his general conclusions to other situations, but for slow learners the need is for a greater variety of experience before generalisations can begin to form in their minds. For the latter 'they do not see' as well as others, and even if they do 'it is not registered in their memory banks'. To illustrate this point, examine the work of two 12 year old boys, in Figures 1 and 2 on the next page.

THINGS TO DO

* Try to pick out the errors (if any) in each of the diagrams.

* What would you diagnose as the possible reasons for the difference in performance of the two boys?

* For each error you locate, what do you think is the root cause for the error? Is it the result of the teacher's teaching?

* What would you suggest as the action that should be taken if you were the teacher teaching the student whose work is represented in Figure 2 on the next page.

Examination of student's work is one of the most valuable source of information available to the teacher. The feedback signals mis-comprehension of concepts taught and inevitably the teacher would have to devise ways of going over the same ground in a way that will bring about appropriate transfer. Hence, of importance to the science teacher are:

° knowledge of problems associated with slow learners in learning science;

- diagnosis of learning problems;
- strategies to help the slow learners learn science.

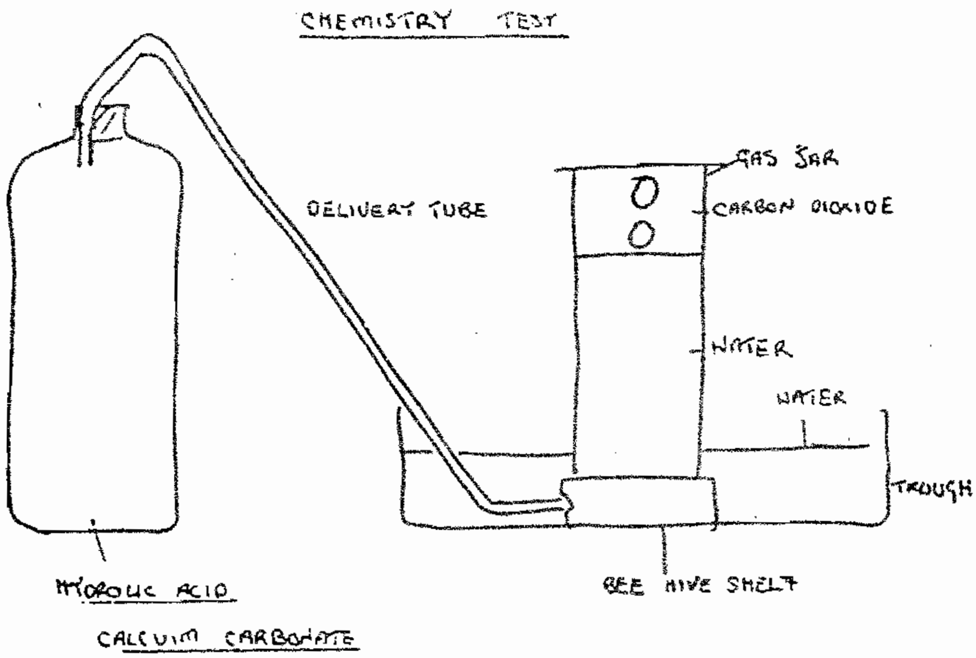


Figure 1

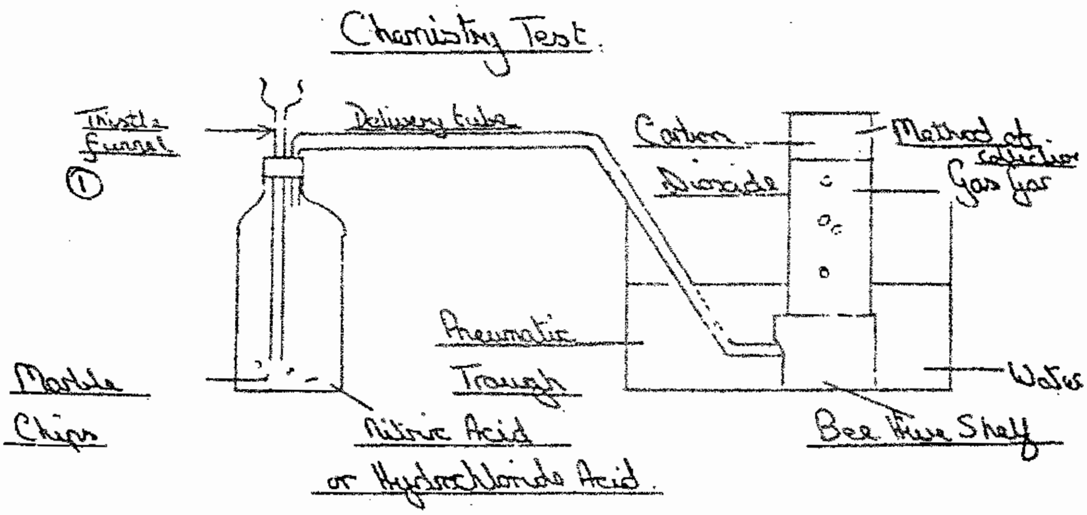


Figure 2

Note: Taken from STEP Series <u>Through the Eyes of the Pupil</u>. London: McGraw Hill. 1974.

KNOWLEDGE OF PROBLEMS ASSOCIATED WITH SLOW LEARNERS IN LEARNING SCIENCE

One of the problems associated with teaching of slow learners is that the problems are not only intellectual. Oftentimes he brings along with him a multitude of emotional ones. His intellectual limitations inevitably puts him on the defensive. The environment appears to him as being designed by 'normal' people for normal people. Streaming, which clusters them together as a group tends to bring out the fact that they are 'below average', and thus discourage them from achieving their best - a self-fulfilling prophesy.

Being unable to learn as quickly as one's friends in the class is upsetting and emotional distress is, in itself, not conducive to effective and rapid learning. On top of this some traditional attitudes are likely to survive too long. The lack of success is only too readily attributed to students' reluctance to respond in the way that their teachers expect. Nonetheless, science has a particular contribution to make for the less able. In fact, contrary to popular belief, the process of scientific inquiry is something particularly akin to slow learners.

* It helps them learn about their surroundings in a way acceptable to them, i.e. relying on sensory experience.

* It is extremely satisfying and valuable to be personally involved and to meet with success in the world which appears to reject them.

* Involvement with discovery helps the child to communicate. So often the slow learner has very little he wants to say and is therefore frequently withdrawn.

Hence rather than teaching factual knowledge, science teachers should take advantage of the fact that their subject lends itself very well to an inquiry approach.

DIAGNOSIS OF LEARNING PROBLEMS

As a beginning teacher you would probably like to find out how you can diagnose learning problems of the students you teach. You may not be able to find out in one lesson, but if you are teaching a particular class for some time, you are bound to find out. Indirect, but often fairly accurate, means are through interaction with students and teacher observations. Through questioning technique and through listening to them, you should be able to tell.

However should you want more concrete evidence there is none better than the students' written work. The hard evidence from their written work often tells a lot (see Figure 1 and Figure 2). Other ways of obtaining feedback include:

- tests,
- checklists,
- school records.

Obtaining feedback is one thing and diagnosing the problems is another. A wrong answer is certainly easy to brush off. A concerned teacher should have alarm bells ringing. Is there a gap between the objectives of science teaching as viewed by her (the teacher) and that viewed by the student? Is the work pegged at the appropriate level? How is it that the students have got it wrong? How are students conceiving about the topic in consideration? Is the approach used the best there is? Is there some other way of delivery? These and many other questions are the teacher's primary concerns in diagnosing failure of students to internalise what is taught.

STRATEGIES TO HELP SLOW LEARNERS LEARN SCIENCE

To develop strategies to help the less able, it is necessary to examine their mental functioning. Unlike the average child, learning by the less able child:

* occurs by comparatively simple mental processes;
* is facilitated by concrete and practical experiences rather than abstract ones;
* should be through experimental work rather than theory;
* should include a liberal amount of drill and repetition.

As a general rule they have short spans of concentration. They exhibit comparatively limited powers of self-criticism. Translated into practice the teaching strategies that should be adopted should therefore:

- provide concrete experiences,
- break up a task into sub-tasks,
- build in success,
- use positive reinforcement,

- encourage involvement,
- have a stimulating environment.

This would mean that small chunks of information given at a time is preferable to large blocks of information. The use of

* programmed texts
* worksheets

automatically lends itself better when teaching the slow learners and should be resorted to wherever possible. Both programmed texts and worksheets have the common feature of providing a small amount of information at a time - a feature that does not overwhelm the less able. These will be taken up in the Theme 2 handbook.

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TOPIC 2 HOW SCIENCE CONCEPTS ARE FORMED

Toh Kok Aun
Chia Lian Sai

INTRODUCTION

Every discipline has its own concepts. In science, for example, gravity, photosynthesis and elements, are all concepts. The ability to present these concepts in an easily digestible form to students is a necessary prerequisite of an effective teacher. Students who have internalised these concepts are placed in a better position to use these concepts in some other situations.

Let us consider the example of cats. There are thousands and thousands of cats which will respond in varied ways under different stimuli. However all these responses show certain common features, such as:

- can mew,
- can climb up a tree,
- can catch mice,
- like eating fish,

etc.

An animal that demonstrates all these features is labelled as a cat. The CAT, as a descriptor of a kind of animal that possesses certain characteristics, is a concept. In everyday life students will be continually bombarded with concepts whether they like it or not. Common examples are tree, school, dog, government, income, freedom, love and many more. Some common examples of science concepts include:

In Physics	In Chemistry	In Biology
magnet	acid	bird
current	catalyst	flower
equilibrium	atom	osmosis
force	valency	photosynthesis
fusion	metal	mammal
mass	solvent	predator
diffraction	sublimation	reproduction

Some of these concepts come automatically, without any formal study. But many of these concepts will have to be acquired in a systematic way through the process of schooling. Sometimes it is a mere reiteration by the teacher as the concepts would already have been in the repertoire of the students' body of experiences. Others are more subtle, and, without formal study, will elude those un-schooled. This article will elaborate on:

* the meaning of concepts;
* concepts used for science teaching;
* how concepts are formed;
* finding out whether concepts are mastered;
* the 'definition-examples-definition' strategy;
* concept mapping.

MEANING OF CONCEPTS

As mentioned at the beginning, the task of the teacher is to find ways of making it possible for students to internalise science concepts. This is necessary so that students:

- learn science without being drowned with the details;
- will find the knowledge they acquire is meaningful;
- can see that they are not confined to current knowledge;
- are provided with a means of acquiring new knowledge.

Having read this far, some of you may be tempted to conclude that a concept is a fact. Far from it. To form the simplest concept, at least two facts or observations that agree are needed, plus at least one more which does not fit into the classification. 'Mammal' is an example of a concept. Several facts can be advanced to convey the idea of a mammal:

- mammals are warm-blooded;
- mammals give birth to their young alive.

Facts can also be brought forth to discriminate between animals that are mammals and animals that are not mammals.

'Living things are interdependent on one another' is a concept of higher order. This is sometimes referred to as a principle, because a range of concepts are involved in such a statement. In other words, a principle is a matrix of concepts encompassing more information than is found in each of the concepts forming the principle.

From the fore-going, a concept is more than a collection of organised facts. Facts are essentially bits of information, while concepts are mental constructs resulting from some form of identity being given to it by the learner. Facts are available to all who perceive them and is public property; concepts are a private possession and represent a personal grasp of some form of relatedness of information.

CONCEPTS USED FOR SCIENCE TEACHING

Essentially, concept is a generic term, and for the purpose of science teaching it is useful to consider the different kinds of concepts.

1. Classificatory concepts : representing a taxonomy of objects with common features, e.g. mammal, reptile, insect, metal, acid, gas, magnet, transformer, transistor, etc.

2. Operational concepts : representing a way of doing something, e.g. parallax, fusion, electrolysis, melting, catalysis, photosynthesis, digestion, respiration, etc.

3. Relational concepts : representing a relationship of two or more bits of information, e.g. mixture, force, density, current, heat transfer, chemical bonding, food web, life cycle, etc.

4. Affective concepts : representing attitudes such as curiosity, inquiry, excitement, patience, love, empathy, cooperation, etc.

While all concepts can be classified under one of the above categories, you should be aware that different observers may not form identical concepts from the same information. One observer may 'see' an amoeba as a non-celled animal and someone else sees it as a one-celled organism (Hurd, 1970).

HOW CONCEPTS ARE FORMED

Research in concept formation has not provided us with any well-defined strategy to assist the teacher in her efforts at getting every student to acquire a particular concept. You would however appreciate the importance of fore-knowledge of how concepts are formed and its ramifications on the way science is taught. In general, forming a concept is a very individual affair and the learner is influenced by:

- intellectual capacity,
- motivation,
- prior background of relevant concepts and information,
- understanding of the teaching,
- conditions of learning,
- suitability of the teacher's mode of instruction.

A significant factor in concept development is the learner's background of experience. According to Dewey, learning is the result of first moving from equilibrium to a state of dis-equilibrium. Students come to class with their own ideas of certain scientific phenomena. If these ideas are incorrect the student's equilibrium will, in the light of the new data or evidence, be brought into disequilibrium. A return to equilibrium signifies some form of understanding of the concept, which may be correct or incorrect. The transition from equilibrium to disequilibrium to a new equilibrium state will be easier for concepts related to physical reality than those which are abstract, such as mass and gravity. Students who are most versatile in the task of encoding and decoding information are more likely to attain a desired concept than those students without this capability. Forming a concept is a process of attempting to organise an unorganised collection of facts. In the process of searching for some logical relationships, the learner invents, constructs and tests them by noting which features characterize most of the data and do not represent other bits of information.

FINDING OUT WHETHER CONCEPTS ARE MASTERED

The student's ability to name or state a concept is not proof of understanding the concept. It could simply represent rote verbal learning. Therein lies the danger of attempting to teach a concept by definition or assertion. A student who can produce a beautiful diagram of the distillation apparatus together with a description of it does not necessarily understand the process of distillation. However, once a concept is correctly formed, the student is on fertile ground. He will be ready to integrate new knowledge with what he has acquired.

The big question is, however, how the teacher can find out whether the concepts taught have been mastered. Basically when a student understands a concept he can be expected to perform through the following:

1. He should be able to choose examples from non-examples, e.g. "that pigeon and that parrot are birds, but that bat and bee are not".

2. He should be able to identify examples of the concept when he meets them, e.g. when he sees a chick, a duck or an eagle, he should be able to say that that is a bird.

3. He should be able to mention the properties/attributes of the concept, e.g. a bird is a warm-blooded vertebrate with wings and feathers.

4. He should be able to solve problems involving the concept, e.g. deducing whether a bird can survive in the polar regions.

By far the best way to test mastery of a concept is to test the learner's ability to differentiate between examples and non-examples. The teacher should therefore resort to giving at least two examples (two facts/observations that agree with the properties/attributes) of the concept, plus at least one non-example (one that does not fit into the classification). The following are some examples.

CONCEPT	PROPERTIES/ATTRIBUTES	EXAMPLES	NON-EXAMPLES
Metal	An element which . has a high boiling/melting point. . can conduct electricity/heat. . has a metallic lustre.	Copper, iron, lead, aluminium, gold.	Iodine, graphite, silicon.
Bird	. A warm-blooded vertebrate, with wings and feathers.	Eagle, kingfisher, pigeon, sparrow, chick, duck.	Bat, bee, butterfly, lizard, cockcroach.
Osmosis	. Transport of solvent particles from a dilute solution through a semi-permeable membrane into a concentrated solution.	Transport of water into . grape, . chili, . root, . a sugar solution in a cellophane bag.	Transport of solute particles through a membrane into water. The solute particles may be . manganate (VII) ions . copper (II) ions etc.

THE 'DEFINITION-EXAMPLES-DEFINITION' STRATEGY

An excellent sequence to explain a science concept is through "definition-examples-definition". In this sequence, the teacher explains the definition, relates examples to the definition, and then repeats the definition. The detailed procedure can be as follows:

1. State clearly the correct definition of the concept.

2. Use two (or more) common (daily life) examples to show the properties/attributes of the concept.

3. Invite some students to provide other examples of the concept.

4. Use some of the students' wrong answers or common errors from class tests, etc., as non-examples, and explain why these are not examples of the concept.

5. Give some new examples and non-examples, and ask the students to identify them.

6. Check students' answers in (5) and give them feedback with necessary explanations to clarify their misconceptions.

7. Summarise by stating again the correct definition, and if necessary invite some students to state more examples and non-examples.

It is important that the examples chosen for explaining should be simple and obvious. This means that the defining attributes of the examples should be clearly recognised, for instance, the feathers of birds chosen should be spread-out visibly. On the other hand, the non-examples chosen are preferably some of the students' misconceptions, e.g. bat and bee are quite similiar to birds and are common misconceptions of students for birds, so they are good non-examples for the concept. It is obvious that the use of this type of non-examples will help students not only understand the correct definition of the concept, but also clarify their misconceptions.

However, to form a more complicated science concept, like a term which links several simple concepts, the student has to master a network of related facts/sub-concepts, e.g.

- Life cycle of frog consists of egg of frog, tadpole, and frog.
- Photosynthesis involves sunlight, green plant (chlorophyll), carbon dioxide, and water.
- A food web includes two or more food chains, each of which in turn involves plant(s) and/or animal(s).
- Transfer of heat may involve conduction, convection or radiation of heat.
- Energy conversion deals with the conversion of various types of energy, e.g. mechanical, electrical, light, heat, magnetic, and sound energy.
- Redox reactions include reduction and oxidation, and involve transfer of electrons.

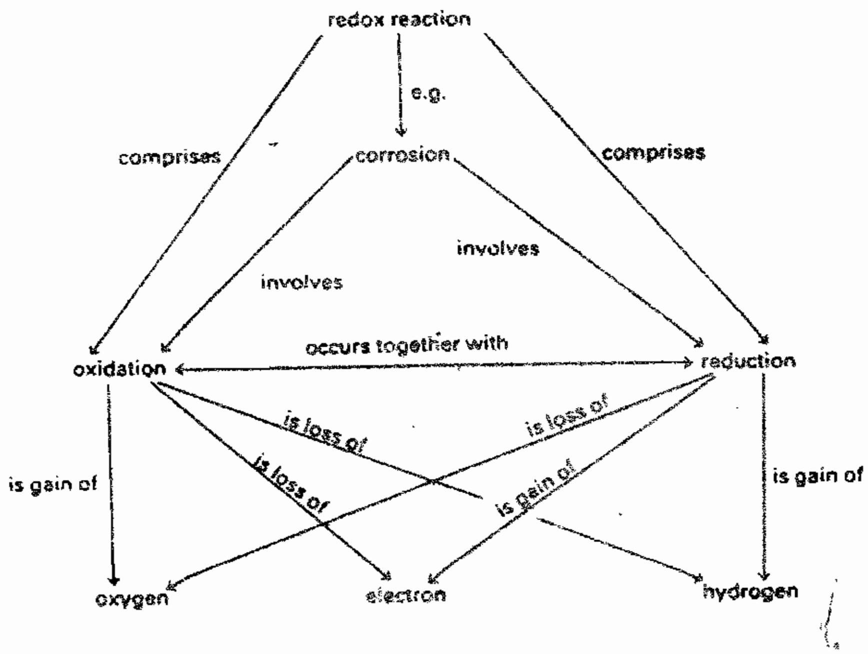
CONCEPT MAPPING

The more complicated concepts like a food web have a logical structure making the facts within the concepts meaningful and therefore useful in thinking. The use of concept mapping is accepted as an aide memoire for teaching and learning the more complicated science concepts.

A concept map is a diagram for representing the conceptual structure of a topic, or a key concept, in two dimensions. A student can use it to show how his knowledge is organised and the extent he has perceived the concepts involved. In principle, a concept map should be able to:

- link related concepts together, and
- give meaning(s) for each link.

The concept map constructed by different people need not be the same. An example of a concept map is shown below.



An Example of a Concept Map

This type of map is usually constructed by experts, teachers or good students who know the topic well. In the teaching and learning of science concepts, a concept map can be used to:

- organise knowledge of a topic;
- classify information into categories and sub-categories;
- rank the concepts involved and show the relationship between various concepts;
- differentiate the key concept from other concepts;
- consolidate ideas about a key concept;
- summarise and review all the concepts learnt in the topic.

CONCLUSION

In this article, we have provided some basic information concerning how students learn science concepts and how they are taught. To teach a simple science concept, at least two examples and a non-example should be given. However, for more difficult science concepts, such as life cycle or energy conversion, a teacher should check whether the student has mastered the pre-requisite sub-concepts. In this case, a concept map will be very useful for teaching and learning science concepts. The "definition-examples-definition", is a useful strategy for explaining science concepts.

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TOPIC 3

EXAMINING THE WAY STUDENTS THINK AND WAYS OF FINDING OUT WHAT IS UNDERSTOOD

Goh Ngoh Khang

INTRODUCTION

Research literature has repeatedly pointed out that unless teachers identify their students' views and design their teaching accordingly, some students' ideas or ways of thinking will not change, or will change in unanticipated ways, when formal science is being taught. As the central focus of all teaching is the learner, it becomes imperative for teaching to be geared towards encouraging understanding of what is learnt. Success in science teaching will depend on how well students understand what has been taught. Finding out how students think and what is really understood thus become essential tasks for the teacher. And as teachers interact with their students' ideas and ways of thinking they can begin to consider ways of correcting them.

PROBING INTO STUDENTS' THINKING

In the context of this article, we will consider students' thinking to mean the mental processes. Two aspects will be deemed important in considering these mental processes.

1. What the student thinks (referring to the content involved).

2. How the student thinks (referring to the process involved).

In the actual classroom situation it is sometimes difficult for the teacher to consider both the 'what' and the 'how'. This is especially so in an inquiry situation where the teacher is involved in a continuous question-answer sequence. In a situation like this it is likely that the teacher may settle for 'what the student thinks', and overlook the aspect of 'how the student thinks'. Unconsciously she may use the 'what' to interpret whether the student has internalised a particular concept taught. How the student arrives at a particular conclusion is therefore being ignored. The following extract from an interview with a student (aged 12 years), serves to illustrate this point. Unless the teacher is prepared to spend time to probe students' understanding she has no way of knowing whether the student truly understands.

Interviewer - Four spoons made of different kinds of material were in a jug of hot water and the handle of the metal spoon felt hotter sooner than the others. Why would that be?

Martin	-	Metal conducts heat better than pot and wood and plastic.
Interviewer	-	Now tell me what you mean by that - that's interesting!
Martin	-	Well, wire conducts electricity ...
Interviewer	-	Yes ...
Martin	-	Well, heat only really is t'same ... Well, metal does really t'same, only with heat it conducts it up it and it goes quicker.
Interviewer	-	What sort of changes would you get inside the metal as the heat was conducted up it, or would you not get any changes?
Martin	-	It'd feel warmer 'cos heat's escaping from t'water and it's going up this 'cos heat rises its going up thro' t'spoon handle.
Interviewer	-	Hmmm. When you say the heat rises, does that mean that if you had your heat - y'know, say you had something warming the spoon at this side you couldn't have water, but, y'know, a little heater or a cigarette lighter or something heating up this end of the spoon, what would happen to the handle?
Martin	-	It'd still get warm but it'd be slower than wi' it being t'other way round.
Interviewer	-	Would it?
Martin	-	Wi' t'heat comin' from t'bottom.
Interviewer	-	It would? Why would it be slower?
Martin	-	'Cos in science they told us that heat rises in water. It goes up, and when you have heat it goes up and it doesn't normally go down.
Interviewer	-	I see. OK, so you're saying that the handle in this position would get hotter, but rather slower than in our original problem with the spoon?
Martin	-	Yeh.

From: Clough, E.E. and Driver, R. (1985). Secondary students' conceptions of the conduction of heat: bringing together scientific and personal views. Physics Education 20: 176-182.

It is interesting to note, in passing, that, in the classroom context, a teacher is likely to be satisfied with a student's initial response and assume a good understanding. But this need not be so.

THINGS TO DO

Examine each of the artifacts below, and discuss, to tease out the implications.

Artifact 1

A question is asked "What will happen to the water level in this jar if we drop a weight into it?".

Drawing from experiences of boating on lakes, of getting into a bath, of putting sugar into drinks, and of jumping onto a bed, students will each generate a different prediction about what could happen.

From: Claxton, A. (1982). School Science: Falling on Strong Ground, or Choked by Thorns? Paper presented in a research seminar.

Artifact 2

Students of all ages hold different views about commonly observed phenomena. However, older students can hold similar views as younger children despite the older students' considerable exposure to science teaching. For example, views such as "bubbles in boiling water are bubbles of air" and "coldness comes through the glass" are held by students over a wide age range. Sometimes, as has been reported by some researchers, students will use scientific knowledge to support their non-scientific ideas. For example, the 15-year old student stated that the water comes through the glass by diffusion.

From: Osborne, R.J., and Cosgrove, M.M. (1983). Children's Conceptions of the Changes of State of Water. Journal of Research in Science Teaching, 20(9): 825-838.

Artifact 3

When grade 6 students were asked to suggest possible answers to the question 'Why do trees have bark?, students proposed explanations which revealed a range of perspectives. Most of the students suggested that the bark was there to serve a purpose for the tree - to keep it warm, to protect it from insects, etc. Others, however, suggested that the bark existed to meet the needs of the animals. Some answers, for example, 'I think that the bark is there to make a tree look nice,' reflected a human-centred view of the world. Others saw the bark as existing to meet the needs of the cats (to help cats sharpen their claws) or small animals (to keep the insects alive).

From: Symington, D.J. (1984). Communication: Process and Product. The Australian Science Teachers Journal, 30(3): 12-21.

Artifact 4

Here is part of a discussion between a teacher and three girls (Margaret, Geraldine, and Anne, aged 12) who are beginning to try to make sense of the largely invisible processes going on in a chemical reaction. A few pieces of magnesium have been added to dilute sulphuric acid, and earlier discussion has established that hydrogen is given off, and that a substance called 'magnesium sulphate' is formed. From a pile of name cards, the girls pick out the names of substances they reason must be in the beaker now, and reject the rest:

T : So what's in the beaker now?

A : Water, and magnesium sulphate.

T : Yes, well there's certainly no magnesium there, so you're right to leave that out. The hydrogen I blew away, so you're right to leave that out. Now this one ... (He picks up the card marked 'sulphuric acid'.) You think there's none of that in there?

A, M, and G : Well, part of it.

A : Part of the sulphuric acid is to do that isn't it?

T : Er ...

A : And hydrogen would be taken out of the sulphuric acid.

T	:	Yes ... (pause) ... so there's no sulphuric acid there now?
M	:	Well there is, but it's joined on to the magnesium.
T	:	Yes ... er ... well, magnesium sulphate ... but there's no sulphuric acid as sulphuric acid left - mm?
Girls	:	No ... no ... no.
T	:	Sure? (He drops another piece of magnesium into the beaker; it fizzes.)
Girls	:	Oh! ... There is!
T	:	Does that show that there is?
A	:	Yes, there is some left.

From: STEP Series (1974). The Art of the Science Teacher. London: McGraw Hill.

Artifact 5

In the study of ecology,

(i) some of the students have problems in learning because of their prior misconceptions. For example, it seemed that because students believed that producers do not occur in water, they failed to include producers in food chains that occurred in water. Examples of students' misconceptions that tended to block understanding of the notion of energy flow in the ecosystem are: the belief that carnivores are stronger than herbivores and thus are able to kill and feed on them; that plants obtain energy from the sun first before consumers take energy from plants, thereby getting less energy; that energy in the second and third feeding (trophic) levels, for instance, add up and are received by the next feeding levels. Beliefs of this sort tended to block understanding of the generalization that available energy decreases as one progresses from producer to consumer levels in the food chain.

(ii) some of the students' misconceptions appeared to have resulted from the instruction. For example, some misconceptions were expressed by the teacher; she included decomposers in the top rung of a pyramid of energy; she also said that bacteria and fungi serve as 'the limit of the food chain' while producers serve as 'the beginning of all food chains'. While it is true that all members of a food chain ultimately depend on producers and, thus, producers always come first in a food chain, it is misleading to suggest that decomposers always terminate a food chain.

From: Ola Adeniyi, E. (1985). Misconceptions of selected ecological concepts held by some Nigerian students. Journal of Biological Education, 19(4): 311-316.

Artifact 6

A dialogue between two brothers on the explanation of bird droppings.

Min Xin : (Age 5+) Small brother, you see. I have already told father to try to avoid parking the car under the tree. But he is so stubborn. Now, you see that the windscreen is dirtied by the birds.

Zhi You : (Age 3+) Big brother, yes. I can see the dirt. But, why do the birds behave in such way?

Min Xin : Oh! It is because birds don't have toilets to go. Not like human beings, they don't know how to build it, because they don't have hands. Usually, birds are free to fly anywhere they like in the sky since higher up there are no traffic lights. If they feel tired, they will take a rest on the tree. Occassionally, they have stomach-ache and they can withstand no further. Then they just let go. As a consequence, they dirty the cars. Understand!

Zhi You : Yes. It is too bad.

Min Xin : Not really. They have no other way.

By careful analysis of the above artifacts, we can conclude that students' ideas might arise from:

* their immediate physical experience;
* the language within their command;
* their beliefs and opinions as influenced by their peers;
* formal and informal instruction.

WHAT PURPOSES ARE SERVED BY UNDERSTANDING THE WAY STUDENTS THINK

An understanding of the way students think will enable us to adjust our teaching to be better adapted to students. This can occur in several ways:

1. **The selection of concepts to teach**

   Some basic scientific concepts in the secondary school syllabus are considered to be obvious and therefore have been taken for granted when teachers plan their lessons. But it is not necessarily the case. Research shows that even some apparently simple notions such as the conservation of matter or the nature of temperature may not be appreciated by many secondary school students. Failure to appreciate such basic ideas will lead to further and more serious learning problems.

2. **The selection of learning experiences**

   If students' prior ideas are known then these can be challenged directly by experiences which conflict with their expectations, thus provoking them to reconsider their ideas. However, challenging students' current ideas is not, by itself, enough to promote change; alternative ideas will have to be offered and these need to be seen by students not only as necessary but also reasonable and plausible. Knowledge of students' ideas enables us to choose teaching activities which are more likely to be interpreted by students in the way intended. It also allows us to reject certain classical teaching experiments, which are not interpreted by the student in the way we expect them to be.

3. **The presentation of the purposes of proposed activities**

   In formulating the purposes of learning tasks it is important to bear in mind that students may reinterpret the intentions of the teacher in terms of their own understandings. It certainly is not easy to find out. A way out is to conduct an open discussion on the purpose of the activity.

WAYS TO FIND OUT WHAT IS UNDERSTOOD

Methods used for identifying students' ideas and hence their understanding about learning certain concepts or skills vary from paper-and-pencil tests, to observational studies in classrooms, to interviews with individual children. Each of these methods provides different types of data and addresses different sorts of questions about student understanding. Below are the common techniques, which can be applied in the school setting, on finding out what is understood.

1. School tests/worksheets and assignments

There are objective questions, which may be of the multiple-choice type, or require a word or a number as an answer. There are also extended-answer questions which require anything from a line to several pages of response, such as structural type or essay type questions. Within all these forms, the recall of a fact may be the case, or a problem might have to be solved. The recall of a fact is generally not regarded as demonstrating understanding, but solving a problem is.

In the following example two ways of setting the same question are shown:

> First Way
>
> Draw a fully labelled diagram of a distillation apparatus and explain how it works.

> Second Way
>
> Suppose that during an expedition to a remote mountainous area you discover that a supply of distilled water is required urgently. You have a kettle, a camping stove and a few bottles. Draw a diagram to show how you would use them to obtain some distilled water. Explain how your method works.

The first way actually tests how good the student is at recalling information from the textbook or from the notebook. But the second way requires the student to apply knowledge of the principles of distillation in an actual situation and is more likely to tell the teacher which points are well understood and which points are not. It involves higher cognitive skills by compelling students to express their thoughts in their own words.

As a result, more application as well as open-ended questions should be set if teachers really want to test their students' understanding. Usually for multiple-choice questions, the distractors are more specific and sometimes artificial. For testing students' understanding, its wide use is questionable. To ameliorate this the teacher can introduce an additional question on 'why do you select this choice?' Careful analysis of the response to this question might provide extra information on students' understanding about the concept tested.

Worksheets and assignments can also contribute to finding out what is understood. But it should change from its traditional ways of design in order to obtain more valid and objective information.

In general, when students work through problems in class, at home or in tests (and examinations), errors made in their answers are evident to the teacher. However, the reasons behind why the errors are made are much less evident. Thus, the student's written work is only of limited value for analysis of problem-solving behaviour.

students are given stacks of cards, each
ı which is thought to be integral to the
:, the terms might be animals, higher
skeletal system, bones, systems, life
ation, digestion, respiration.

:, the terms might be kinetic theory,
emperature, matter, molecules, gas, liquid,
:ance, average speed.

ıstructed to place the cards on a large sheet
elated terms are close together. Lines are
etween related terms and the nature of the
en on the lines. The map which results is a
sentation of the way the student sees a
knowledge; it is a measure of understanding
discipline, at least a large topic within
: is quick to administer and can be used with
/ields only a rough assessment of depth of
: page 24 for an example of a concept map.

:tical sessions, whether students really
:ructions and are able to follow them will be
eir process skills, especially manipulative
sment of such skills can only be carried out
ough direct observation. For simplicity and
ll checklisting approach is encouraged.

4. Discussion/Questioning

In the classroom setting, the immediate way to get feedback about students' understanding about the concept(s) taught is to ask open-ended questions as well as application type of questions. Discussion of problems can also be conducted not only with whole classes but also in small groups. A technique involving prediction-observation-explanation can be applied. For instance, students are shown a block and bucket hanging side-by-side on a pulley; the block is pulled down and they are asked what will happen when the block is released. Reasons for the prediction are requested. The block is then released and the students are asked to record what they observed. Any discrepancy between prediction and observation has to be explained. The teacher should realize that students need opportunities to explore their ideas in a non-threatening environment. Creating this environment during discussion/ questioning to allow for the open exploration of ideas is a challenge for science teacher.

5. Interviews

(i) About a concept or a single element

While concept mapping is used with large parts of a discipline, interviews usually deal with single concepts or, finer still, single propositions. The aim in such interviews is to obtain as complete as possible a set of elements of knowledge that the student relates to the concept's name or to the target element.

A wide range of procedures for an interview is possible. One of them is to use specific questions such as "which way would you look to see ...?", and a range of objects and diagrams in highly structured procedures.

Another way is an open procedure using higher level students to tell all they know about a topic, then asking them for images and episodes related to it.

(ii) About the students' problem-solving behaviour

Usually the "thinking aloud" method of problem solving is used. The method is described as follows:

A few students are asked to participate in the experiment, which will take each of them an hour at the most. One or more relevant problems are chosen. The experimenter and the subjects work in a room where they cannot be disturbed. Possibly a third party is present to operate the tape recorder and to record tape numbers corresponding to any notes taken. The experimenter concerns himself only with stimulating the subjects to think aloud. He gives clues only when the subjects reach an impasse. He should avoid teaching during the experiments but should feel free to give feedback afterwards.

The problem-solving process can be observed directly when students try to solve the problem while thinking aloud. The tape can be studied more thoroughly later. When it is considered worthwhile, the tape recording may be transcribed; the result is called a protocol. As we apply the "thinking aloud" method, the psychological barrier due to the unusual situation as well as the hindrance of the thinking process through verbalizing thought or vice versa, should be taken into consideration. This is the disadvantage of this method.

CONCLUSION

In this topic the importance and purposes of examining the way students think are explored. Different ways of finding out what is understood are also discussed. The ramifications of this on the way a teacher decides on how to teach a topic is tremendous.

Although certain techniques, such as interviews, are sensitive, they are time-consuming. In order to obtain some general patterns of understanding about scientific concepts, principles or the problem-solving behaviour over a population, a combination of techniques can be used. For example, a researcher can combine the sensitivity of the interview with the power of the mass test by deriving from the interviews three opinions about heat and temperature. These opinions are then incorporated as alternatives in a multiple-choice test. In fact, all these techniques are fundamental tools for teachers to find out about their students' thinking and understanding. How much information the teacher can obtain depends on how skillful she is in understanding her students. This will, in turn, have ramifications on how she approaches a topic.

TOPIC 4 PLANNING FOR SCIENCE INSTRUCTION WITH OBJECTIVES IN MIND

Ruth Chellappah

WHY PLAN ?

Pros (+ve)	Cons (-ve)
Planning assists the teacher to:	Some people claim that lesson planning is:
. specify purposes of lessons clearly;	. unnecessary;
. provide for student involvement in discussion and practical work;	. stifling to curiosity;
. ensure that no crucial points are omitted during the lesson;	. time consuming;
. include suitable activities to enhance understanding of concepts;	. restrictive;
. select suitable teaching resources;	. troublesome;
. decide on the effectiveness of the method used to teach specific topics;	. difficult.
. decide on the teaching strategy to use for different ability groups, if teaching similar subject content.	Teachers may find it too difficult to modify their lessons to suit changes in classroom context. Teachers may be so fixed on completing their prepared objectives/lesson that they do not pay attention to students' difficulties or problems in learning. They become too inflexible in their teaching.

Planning can also:

- help some other teachers to take over, if necessary, after a brief study of your plan;
- help the teacher cater to a variety of methods, activities and abilities;
- help in long range allocation of personnel, funds and resources.

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TOPIC 4 PLANNING FOR SCIENCE INSTRUCTION WITH OBJECTIVES IN MIND

Ruth Chellappah

WHY PLAN ?

Pros (+ve)

Planning assists the teacher to:

- specify purposes of lessons clearly;
- provide for student involvement in discussion and practical work;
- ensure that no crucial points are omitted during the lesson;
- include suitable activities to enhance understanding of concepts;
- select suitable teaching resources;
- decide on the effectiveness of the method used to teach specific topics;
- decide on the teaching strategy to use for different ability groups, if teaching similar subject content.

Cons (-ve)

Some people claim that lesson planning is:

- unnecessary;
- stifling to curiosity;
- time consuming;
- restrictive;
- troublesome;
- difficult.

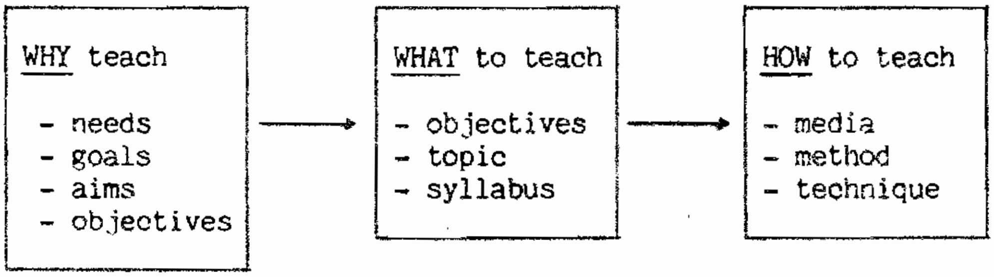
Teachers may find it too difficult to modify their lessons to suit changes in classroom context. Teachers may be so fixed on completing their prepared objectives/lesson that they do not pay attention to students' difficulties or problems in learning. They become too inflexible in their teaching.

Planning can also:

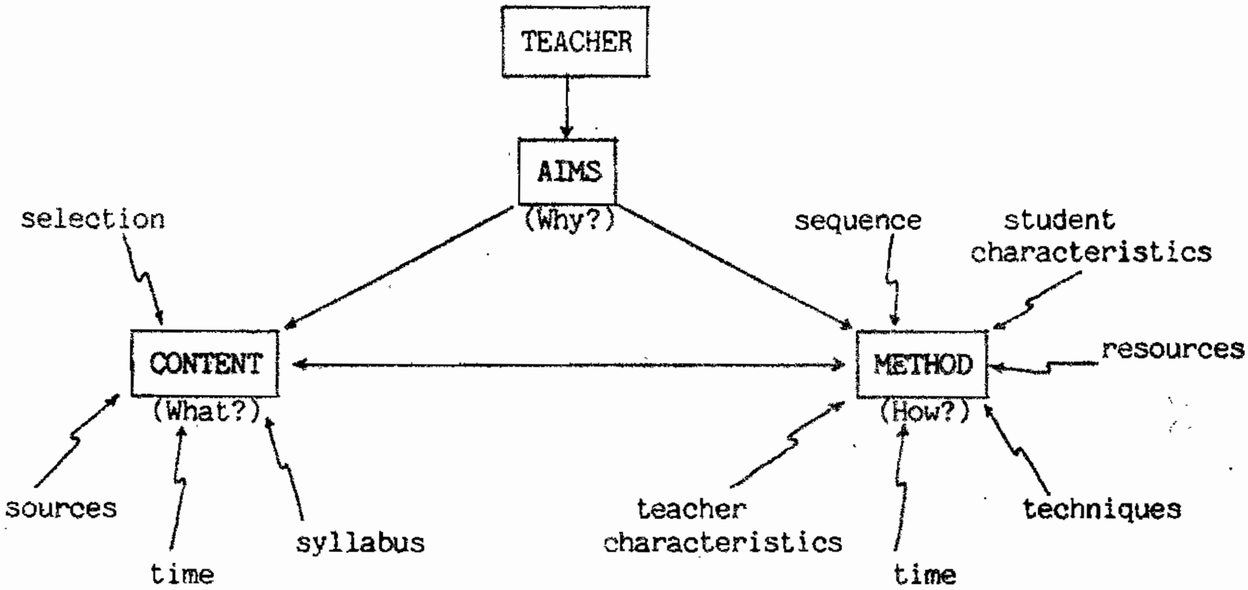
- help some other teachers to take over, if necessary, after a brief study of your plan;
- help the teacher cater to a variety of methods, activities and abilities;
- help in long range allocation of personnel, funds and resources.

PLANNING IS DECISION MAKING

Before preparing a lesson, the teacher should always ask herself these questions:



In planning your science lessons you should try as far as possible to create a situation where your students actively confront new ideas or concepts being taught. The aims of a lesson or unit (WHY the subject is taught) should logically determine the syllabus content (WHAT exactly is taught) and the teaching method (HOW the subject is taught).



GUIDE TO PLANNING YOUR LESSONS

Let us assume that the aim of the teacher is to get her students to understand some scientific concepts which are part of the syllabus for a subject. When she plans to teach the concept to a normal class, for example, she may decide to use a film (method) to illustrate the application of the concept. When she plans the same lesson for the express science class, she has to plan for a practical to illustrate the application of the concept (method). Here her aims (from the syllabus for express and/or normal stream) determine what goes into the content which then determines the method to be used.

In her lesson plan the teacher would need to determine the time sequence of her lesson, i.e. when to show the film - (either as an introduction or to conclude the lesson) or when to schedule the practical session.

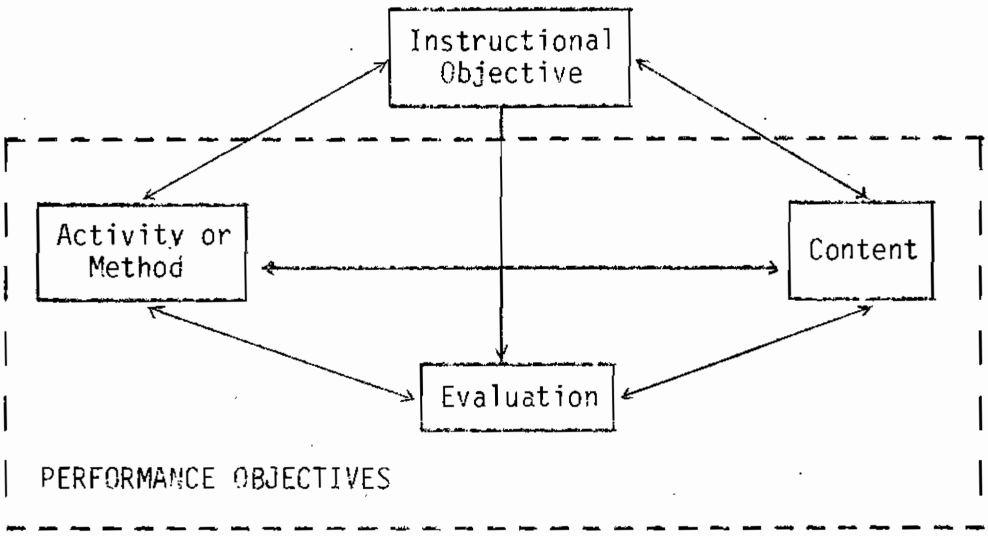
On the other hand, if the teacher's aim is to foster closer interaction and co-operation among her students, the teacher would choose a situation where the students can work together on a project (method). Here the aim determines the method.

In planning a lesson the teacher should take into consideration:

- the overall objectives or goals of the course;
- the group to be taught (student ability/needs/interests);
- the time available;
- the resources available;
- the subject matter;
- the learning activities;
- the nature of evaluation;
- facilitation for improved teaching.

This will determine how objectives are to be written. Formulating objectives in lesson plans have many benefits. Teachers must decide what they want their students to know at the end of the course, which was not known at the beginning. An instructional objective is therefore a statement of what a learner is expected to learn at the end of some instructional activities. It is desirous to state the objective in the form of student's expected level of performance rather than the teacher's intention of what to teach. This is done to emphasize the importance of what is mastered rather than what is taught. When the objective is put in the form of the student's expected level of performance it is called a performance objective or a behavioural objective. To be acceptable as a performance objective, the objective must be:

- clear
- demonstrable
- measurable



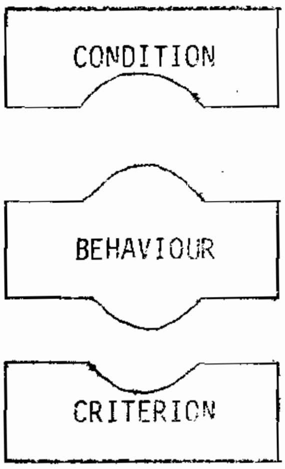
A performance objective is thus a specific statement of intent by a teacher about the changes in performance that a student must show as a result of a teaching programme. The emphasis is on student performance rather than teacher performance or teacher intention. This is especially important when planning for lower ability students. The teacher who teaches in a similar manner in two classes, one of which is a lower ability class, may have performed, but if the lower ability class fails to master the content of the lesson, the intent is lost.

WRITING PERFORMANCE OBJECTIVES

Formulating good performance objectives involves the inclusion of three aspects:

* a condition
* a behaviour
* a criterion.

in each statement of performance objectives. These 3 aspects are described below.



CONDITION: which includes a statement of the condition under which the student will perform (i.e. what the student can do at the end of the lesson)

BEHAVIOUR: which includes a verb describing the behaviour or performance expected of the student

CRITERION: which includes a criterion of acceptable performance (i.e. level of performance)

In writing performance objectives for science:

AVOID words such as:	USE words such as:
know	state
comprehend	recognise
learn	predict
appreciate	compute
understand	use
is aware of	list
respect	select
think	show
create	correct

The intention of any performance objective is to make the objective unambiguous so that everyone who reads them gets the same meaning out of them. The choice of precise verbs (see above) is thus important. There are two ways of writing performance objectives in an unambiguous manner; one is suggested by Mager and the other by Gronlund.

Mager's Approach	Gronlund's Approach
Write all the performance objectives using terms which describe only the specific observable performances as intended learning outcomes. Example Given the necessary apparatus and chemicals, students should be able to identify three cations and two anions in the mixture within an hour. In the objective above, . "Given the necessary apparatus and chemicals" communicates the conditions, under which the student is expected to operate. . "identify" communicates the desired behaviour or performance. . "three cations and two anions ... within an hour" communicates the criterion of acceptable performance.	Use non-observable terms to describe the general learning outcomes but further clarify such terms by a sample of specific performances which can be accepted as representative of the intended general learning outcome. Gronlund's suggestion is to have the objectives stated at two levels, i.e. the general and the specific. General objectives are useful as a basis for teaching, whereas the specific objectives should be the basis for testing. Example General Objective To understand Newton's Laws of Motion Specific Objectives - State Newton's Laws of Motion - Define force, momentum, action and reaction - Explain units of force - Derive $F = ma$

The choice is up to the teacher. The two approaches may appear different, but in essence they achieve the same thing. In Gronlund's approach, the use of specific verbs to describe the desired behaviour or performance has to be adhered to strictly. Mager's approach tends to end up with a long statement while Gronlund's approach breaks up a statement into small components or concepts to be developed.

PLANNING FOR SCIENCE PRACTICALS

When planning for a practical session, we would want to identify the basic aims of a science teacher in including practical work for her students. Two of the fundamental aims of doing practical work seem to be:

* developing practical scientific skills and techniques in our students;

* developing problem-solving skills.

The range of practical skills that we need to develop in our students can be identified as the process skills of observation, measurement, estimation and manipulation. That is, the ability to observe carefully, honestly and perceptively; to recognise similarities and differences; to appreciate what is significant in our results; and, to be able to measure a variety of properties using various scientific instruments. Manipulative skills will need to be developed so that students can handle apparatus and equipment safely and correctly.

A scientist works as a problem solver and so should our students. Students need to be given (or should suggest for themselves) a problem, and be encouraged to analyse the problem, decide on relevant parameters and formulate ideas to be developed and tested during practical investigations. Students should learn to evaluate their findings and modify their procedures accordingly. This is called open-ended divergent thinking. We should also try to develop lateral thinking in students during investigative problem-solving project work. In this respect students should be encouraged to look at a problem in as many different ways as is possible.

Appended to this article are three examples of lessons planned for science classes. The sample Physics lesson is a lesson on electromagnetism. Here the teacher plans to use the example of an electromagnet, as is found in a crane, to introduce the concept of electric current producing a magnetic field in a straight wire.

In the sample Chemistry lesson, the plan is to prepare carbon dioxide gas, and to involve students in the experimental investigation of the physical and chemical properties of the gas with the aid of a worksheet.

In the sample Biology lesson, the teacher has planned an investigative practical to compare the structures of a typical plant and animal cell. Here too, students will be given a worksheet with guidelines to follow and a series of questions that will guide them, through the use of various process skills, in their investigation.

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LESSON PLAN FOR PHYSICS

Class : Secondary 4 (Express)

Duration : 2 periods (35 minutes each)

Subject : Physics

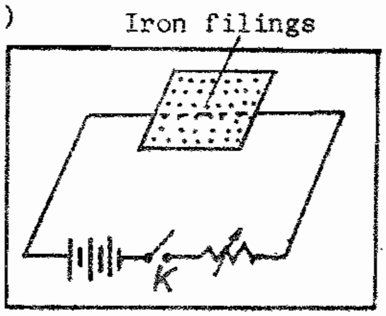
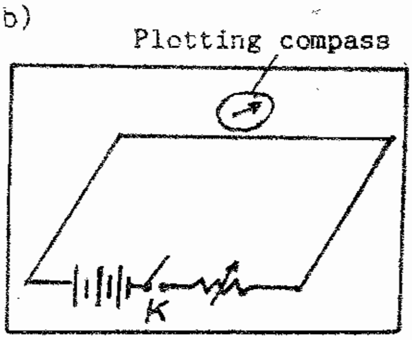
Topic : Introduction to Electromagnetism

Concepts to be learnt :
1) Magnetic field due to electric current in a straight wire.
2) Right-hand grip rule.

Objectives : At the end of the lesson, students should be able to:
1) draw the magnetic field due to electric current in a straight wire; and
2) apply the right-hand grip rule.

Materials : Transparencies, handouts (No. 1 and 2), iron filings, wires, key, plastic plate, lead accumulator (or a transformer), compass.

Content	Method	Time
1. Introduction	Introduce a discussion.	5 min
- an example that may suggest a relationship between electricity and magnetism	Transparency 1 shows a junk yard.	
e.g. 'In a junk yard, a crane lowers a thick metal disc into a pile of scrap metal, and large pieces of metal can be raised.		
We see cables here!'	Ask: Is there some kind of relationship between electricity and magnetism?	

Content	Method	Time
2. 'It was quite by accident that Oersted discovered that electricity has magnetic effects. He discovered that a wire carrying a current was able to deflect a pivoted magnetic needle'.	Brief mention of Oersted's discovery by teacher.	5 min
3. Simple experiments to show the magnetic effect of a current a)  b)  	Demonstration - students to make close observation. Ask: a) What happens when key K is closed? b) i) What happens when key K is closed? ii) What happens to the needle when the direction of current flow is reversed?	10 mins
4. i) A current has a magnetic effect. ii) A change in the direction of the current flow, changes the direction of the magnetic field.	Summary by students. The teacher may like to list them on the blackboard.	5 min

LESSON PLAN FOR CHEMISTRY

Class : Secondary 2 (Express)

Duration : 2 periods (35 minutes each)

Subject : Lower Secondary Science

Topic : Preparation and properties of carbon dioxide

Objectives : At the end of the lesson, the students should be able to:

1) describe the preparation of carbon dioxide including the experimental set-up;

2) write down the word equation for the reaction involved; and

3) discover experimentally some of the physical and chemical properties of carbon dioxide.

Materials : OHP, flat-bottomed flask, thistle funnel, delivery tube, trough, gas jar, marble chips, hydrochloric acid, test-tubes, wooden splints, dishes, lime water, sodium hydroxide and litmus paper.

Previous Knowledge : The students have already had some background knowledge about the carbon cycle.

Introduction : The lesson will begin with the teacher asking the following questions:

1) Can you name some of the natural processes producing carbon dioxide?
(Respiration, combustion, organic decay)

2) What do you think of these processes for preparing carbon dioxide?
(Not convenient)

3) In the laboratory, how do you think we can prepare carbon dioxide?
(Using chemical reagents - an efficient way is the action of dilute hydrochloric acid on marble chips)

5 mins

Development : 1) Students will be told of the chemical reagents used and the word equation in the reaction for the preparation of carbon dioxide, i.e. calcium carbonate + hydrochloric acid = carbon dioxide + calcium chloride + water.

2) Explanation of the experimental set-up: Students will be told the different parts of the set-up, i.e. the flat-bottomed flask, thistle funnel, delivery tube, trough, gas jars.

3) Demonstration of the preparation of carbon dioxide: Each step of the procedure will be explained to the students, as the experiment proceeds, with emphasis on the precautions taken, i.e. the tip of the thistle funnel is placed below the acid level (so that the carbon dioxide will not escape through the thistle funnel), and the first few bubbles of gas are not collected (so that the carbon dioxide collected will not contain impurities).

20 mins

4) Activities: Each group of 4 students will complete Expt. 10, viz. to investigate some of the properties of carbon dioxide.

The properties investigated will be colour, taste, smell, combustion-supporting property, solubility in water, action on moist litmus paper (acidity), solubility in sodium hydroxide and action on lime water.

The students will be given time to read the worksheet for Expt. 10. They will then be briefed on important points in the procedure.

30 mins

Concluding the lesson : 1) At the end of the experiment, a review of the procedure for the preparation of carbon dioxide will be made by asking the students to give the sequence of steps in the preparation.

2) Each student will be asked to write down the notes on the preparation and properties of carbon dioxide, which include the word equations, the procedure and the experimental set-up.

3) Collection of students' reports.

15 mins

Evaluation : 1) How many students will be able to achieve Objectives (1) and (2)? (from assessment test to be given at a later date)

2) How many groups of students have achieved Objective (3)? (from students' reports)

3) Self-evaluation: On the basis of (1) and (2) above, do I feel that my lesson is successful?

LESSON PLAN FOR BIOLOGY

Class	: Secondary 3 (Express)
Duration	: 2 periods (35 minutes each)
Subject	: Biology
Topic	: Microscopic Examination of Cells (Practical)
Concepts to be learnt	: 1) The smallest unit of life capable of existing independently is the cell. 2) The cell consists of many different parts. 3) Each part functions in a special way. 4) There are many types of cells. 5) All living things are made of cells.
Objectives	: The students should be able to: 1) draw and label the transverse sections of the cells seen under the microscope, and state the magnification; 2) compare and contrast the size and structures of the various cells; and 3) complete the worksheet containing questions based on the practical.
Materials	: Onion, eye dropper, water, small paper cup, glass slide, iodine, ink (or methylene blue stain), glass cover slip, knife, toothpick, microscope.
Laboratory preparation	: 1) 20 microscopes will be set up by the laboratory assistants and placed on the students' benches. 2) 20 sets of apparatus, one for each pair of students will be placed on the benches by the side of the microscopes. 3) Each student will be provided with an investigative worksheet to complete.

Students' previous knowledge : 1) Theory on the structure of the plant and animal cell was taught earlier.

2) Students are familiar with the use of the microscope.

Development : a) The aims and procedures of the practical will be outlined and discussed with the students.
10 mins

b) Organisational chores to be attended to by the teacher include:

- briefing on precautions when using the microscope;
- pairing off the students for practical work;
- issuing each student with a worksheet.

c) Students will be given the rest of the time to complete the worksheet. The teacher will supervise students during the practical, and provide necessary guidance, where necessary.

Open-ended Questions (for group discussion with the teacher during the practical)

- What are some similarities and some differences of all living tissue?
- How long can living tissues exist without water?
- How would you go about finding out?
- How could you find out what effect prolonged darkness will have on living tissue?

50 mins

d) Students will be reminded to wash the apparatus used, throw away used material and clean the microscopes before leaving the laboratory.
10 mins

e) Students will need to hand in completed worksheets to the teacher before they leave.

Evaluation : 1) Did the students use the microscope correctly?
(while the lesson is in progress)

2) Were the objectives achieved within acceptable limits?
(from assessment of worksheets)

3) Self-evaluation: On the basis of the above, do I feel that my lesson is successful?

WORKSHEET

WHAT IS A CELL?

Processes

1. Cut the onion in half. What do you notice about its structure? Draw what you see. Label all parts.

Observing

2. Peel off an inside ring of the onion. From this ring, pull off the outer layer of tissue. This layer should be as thin as tissue paper. Place this tissue in a drop of water on a glass slide.

Hypothesizing

What do you think will happen if you place a drop of iodine on the tissue?

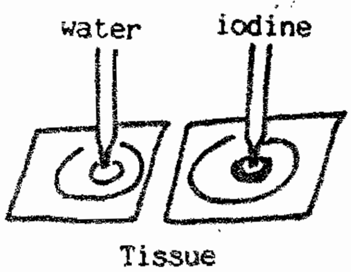


Figure 1

3. Place a drop of iodine on the tissue.

Observing

What effect does iodine have on the onion tissue?

Inferring

How will this help you to see the tissue?

Observing

4. Observe the tissue through the microscope.

Record your observations.

The small things you see are called cells.

Observing

How are these cells arranged?

Teacher's Note: The student should see what is illustrated in the diagram below.

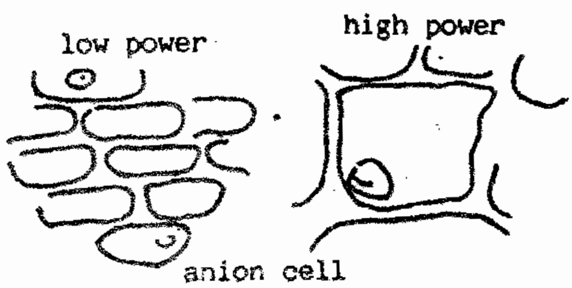


Figure 2

	Processes
What do you think you will see if you look through the microscope under high power?	Hypothesizing
5. Try the high power.	
What do you see?	Observing
How could you find out what the parts of the cell are called?	Designing an investigation
How could you find out about the functions of these parts?	Designing an investigation
How do you think human tissue is similar to plant tissue?	Inferring
How would you find out?	Designing an investigation
6. Obtain a toothpick, a knife, a glass slide, and a coverslip. Gently scrape the inside of your cheek or lip with the toothpick. With a knife, scrape some of the white material on the toothpick into a drop of water on a glass slide. Then add a drop of iodine.	
7. Spread the material out in the water and place a glass cover slip over it. Examine the material with your microscope under high power.	
What do you see?	Observing
How are the cells similar to those you saw in the onion tissue?	Comparing
From what you have observed, what could you say about living matter?	Inferring

CSO/THEME 1

TOPIC 5 ON CLASSROOM CONTROL, AFFECTIVE DEVELOPMENT AND THE SCIENCE TEACHER

Toh Kok Aun

INTRODUCTION

Many from outside the sphere of education seem to take the view that teaching is a simple task. We cannot really blame them because they may conceive the teacher to be synonymous with the role of purveyors of facts and knowledge. The role and responsibilities of the teacher has expanded tremendously. When you think of young people being put into their care for a good part of the day, you will realise the importance of the teacher's role in the development of the child. In fact a good teacher will need to possess a combination of rare qualities. A teacher is a/an

- planner
- instructor
- manager
- evaluator
- organiser
- disciplinarian
- counsellor
- judge

That is quite a mouthful, isn't it? When you think of all these roles expected of a teacher you will realise it is a tall order. Every subject teacher will have to play a part and the science teacher is not exempt from any of these.

As a science teacher you will need to help students not only in learning facts, understanding them, developing cognitive and practical skills, but also in developing their attitudes and values, i.e. affective development. Even if the teacher professes no concern about affective development, it will probably happen regardless. What, for example, are the consequences of doing nothing when:

- a child carelessly breaks a piece of apparatus?
- the class rushes out at the end of the lesson without clearing up the materials used in that lesson?
- a student cheats in a test?

GENERAL EXPECTATIONS

Having said the above, I hope you have a clearer picture of the expectations required of a 'performing' teacher. Because the success of any effort to improve the quality of education depends finally on teachers - their capacity, what they do, and how they see their role. The general expectations can be summarised as:

* Appreciation that teaching of science involves affective as well as cognitive and psychomotor outcomes.
* Ability to plan and respond to teaching situations in such a way as to foster the affective development of students.
* Exhibit flexibility in response to problems in the classroom.
* Perceptive understanding of the process involved in teacher-student interaction.

TEACHER'S INFLUENCE ON STUDENTS' ATTITUDES AND VALUES

What a teacher does, the teacher may forget and brush off as of little consequence. To the student, there may be some lasting effects, and will be remembered for a long time to come. What a teacher does or says will bring about tremendous repercussions at times. The following are some situations you may wish to discuss and generate professional solutions:

Activity One

1. Several of your Secondary Two students did not hand in their homework at the end of the last lesson. You ask each of them for reasons and receive the following explanations:

   - I lost the questions.
   - I hurt the fingers of my right hand.
   - I was away when you collected the homework.
   - I just forgot.
   - Hsui Mei took my book.

   What action do you propose to take in each case and why?

2. Your Secondary Three co-ed class of average ability is carrying out an experiment in the laboratory. The following situations have cropped up. What action do you propose to take in each case and why?

   a) 'Miss Low, I haven't got a partner.'

   b) There was plenty of chemicals at the start but all has now been taken and six students haven't got any.

   c) 'My experiment doesn't work.'

   d) A student is doing all the work while her partner just watches.

   e) Water is spilt all over two students' books.

   f) After 15 minutes two boys are still talking and have not started on their experiments.

   g) One student sticks a dropper into the gas tap and breaks it.

   h) One student approaches you for permission to borrow home a dropper, test-tubes, and a measuring cylinder, to finish the experiment at home.

3. You and your class arrive at an untidy laboratory with previous lesson's materials spread over the benches. Discuss the actions you propose to take and the possible affective outcomes.

4. Suggest two possible alternative actions and their probable affective outcomes for each of the following:

   - experiment fails to work for half the class;
   - some plotting compasses are missing after the practical;
   - one student is using the gun-type of flint lighter as a 'gun' - firing away at his neighbours.

Activity Two

What kinds of behaviour are we concerned to try to develop in our students? Which of these qualities included in the list below are the prerogative of science, as opposed to the other subjects in the school curriculum?

cooperation	diligence	respect for
self-reliance	reliability	resourcefulness
initiative	honesty	love of nature
helpfulness	responsibility	patience
unselfishness	sympathy	efficiency
confidence	curiosity	tidiness
leadership	thoroughness	enjoyment
perseverence	interest	conscientiousness

DISRUPTIVE BEHAVIOUR

Some situations which will promote affective development will arise spontaneously during teaching. Some could even be planned for by the teacher specifically to meet particular affective objectives. It will probably be best to casually instil attitudes instead of deliberately doing so. All said, there will however be occasions when it is necessary for the teacher to take positive actions against disruptive behaviour. Failure to do so would imply softness on the part of the teacher. At the same time an overly harsh response will leave some lasting impressions upon the student.

Activity Three

Analyse the following incidents, criticising each other's solutions by asking the following questions:

- Is this a professionally acceptable answer?
- Is it a reaction of panic, or just an attempt to escape from the situation?
- Are there possible consequences for each solution?

The following are the incidents:

1. You arrive in the classroom to find the chalkboard covered with obscene language referring to you.
2. You arrive for your lesson to find two boys fighting viciously in one corner, with the rest of the class cheering on.

3. You are in the middle of your last sentence when the school bell goes for the end of the lesson. Like one man, all the students rise from their seats and start to leave.

4. You have just collected the students' papers, having given them a test. They have all left the room except for one boy who approaches you and says 'Please Sir, I don't know if I should tell you but Peng Seah was cheating - I saw him with a crumpled sheet of paper on his lap.'

SANCTIONS - THE PROS AND CONS

The following are some sanctions. For all they are worth they are bound to have implications. The following is an attempt to objectively view some of them.

SANCTION	ADVANTAGES	DISADVANTAGES
Corporal Punishment (sending to principal or discipline master to be caned)	Immediate impact; may relieve the teacher's feelings of just indignation and so prevent ulcers.	Frowned upon because it may cause psychological harm to sensitive students; may corrupt student-teacher relationships; barbaric; may cause others to hero-worship the one punished.
Detentions	Systematically administered, it provides a smooth machinery for an impersonal retribution, and a record of the chronic malefactors.	System breaks down with persistent offenders; causes friction with parents; often clashes with desirable extra-curricular activities; teacher who gives the detention must ensure that the time is NOT used for doing homework by setting some disagreeable work to be done and seeing that it is done.

SANCTION	ADVANTAGES	DISADVANTAGES
Impositions	Flexibility - the punishment can be tailored to fit the crime.	The hardened offender knows so many dodges for making light of an imposition that the teacher may have to spend much more time and trouble seeing that it is done in the spirit in which it was imposed.
Keeping a whole class in after school	Makes it possible to punish offenders whom the teacher cannot isolate from the class.	Fails to discriminate between the innocent and the guilty; it punishes the teacher also, in that she has to stay in with the class; creates resentment with innocent students of the class; resentment from parents too; strain on teacher in that the teacher has to supervise the detention herself.
Verbal abuse ("Nagging")	Immediate effect; allows teachers to get it out of her chest; no pain or inconvenience caused to the teacher; the dose can be adjusted to the needs of the recipient. N.B. When using this sanction, essential to be brief and then quickly switch from invective to normal communication.	Most of us are either not talented enough or overly so; if too talented we develop the habit of caustic comment which causes lasting resentment; if not talented we run into the danger of being ineffectual and ridiculous.

SANCTION	ADVANTAGES	DISADVANTAGES
Sending the student out of the classroom	Rids you of a distracting nuisance so that you can concentrate on teaching the rest of the class.	Offender is not learning and the school principal may not be too happy with this approach (unless you set him a task to do!); if no task is set, it has little deterrent value.

SOME NOTEWORTHY HINTS

Teachers are statutorily prohibited from using physical punishment. Punishment must produce some deterrent effect otherwise the object of the punishment is lost. Scolding or nagging is punishment; the ear is being punished. The following are some hints culled from a variety of sources for discussion; it should not be assumed that they are efficacious or even wise!

1. Do not take unruliness or impertinence as either some form of personal insult or a sign of your incompetence. Students try it on everyone. Keep your personal feelings out of the business of discipline.

2. Except for the odd truant cases, the majority in a class want to obey their better instincts of cooperativeness, but without the firmness of the teacher they may succumb to the leadership of the troublemakers. Students are made uneasy by signs of lack of self-confidence, indecisions, and contradictory instructions. Try to know exactly what you want them to do, make sure they understand, and insist on it.

3. On first acquaintance the difference in status between yourself and your charges needs emphasizing. When one is bald and venerable it is time to minimise it.

4. To some people, punishment is a confession of failure. If it is a confession of failure then every teacher must fail at some time with some students. A little prompt punishment is kinder to everyone than a lot of unavailing punishment later on.

5. Be alert to signs of restlessness and switch quickly to some activity, which involves the whole class.
Inactivity = boredom = trouble.

6. Learn the names of your students as soon as possible. (A useful tip: When you give out exercise books keep back one or two and give them back to their owners with some comment on the quality of their work. Thus you can establish personal contact and build up a growing nucleus of known students.)

7. Don't talk to the chalkboard.

8. Some people will tell you: You can forget all these hints if you can learn to love <u>all</u> your students, including the most troublesome ones.

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TOPIC 6 FOSTERING A BETTER TEACHER-STUDENT INTERACTION DURING SCIENCE LESSONS

Toh Kok Aun

INTRODUCTION

In the previous five topics much emphasis was given to the teacher's perception of the students' needs, on the importance of knowing matters pertaining to how students think, and responding to it. The way for example, in which a teacher handles an incident is treated in terms of how the teacher interprets the reason for a student's behaviour. A student with a misbehaviour problem would be treated in a specific way by the teacher depending on whether her diagnosis of the problem is because the student:

- was bored;
- wanted to gain acceptance by his peers;
- was testing how adults behave under stress.

In this light, the teacher's reactions and subsequent sanctions are intended to help students resolve their problems, re-form their behaviour (or modify their behaviour, as Skinner would have put it). Depending on the teacher's conclusions the sanctions could therefore be intended as a deterrent or something which would not be considered as punitive at all.

STYLE OF TEACHING

A democratic approach in which a teacher exercises authority is based upon the concept of the students' need. When students view their teachers to be an asset, it is because they recognise the teacher as having met their needs. This trust, once built up, would mean the students' acceptance of being subjected to a certain degree of authority imposed by the teacher. This is different from the authoritarian approach where the teacher knows best and therefore seeks to impose her control.

Undoubtedly the approach adopted by the teacher would almost certainly be influenced by how she views her students can best be motivated. For the science teacher, if motivation features strongly within her considerations, there should be a preference for activity and discovery in her delivery styles. A beneficial by-product would be the thinking processes being promoted by these styles. Thus the teacher's attitude to motivation, will determine her choice of teaching method and so the kind of educational objective she hopes to achieve.

Research evidence suggests that students are more likely to develop certain affective qualities when the class structure is less formal. The teachers operating in this way place most value on higher cognitive and affective objectives. On the other hand the dogmatic assertion of one's view (the teacher's) would be contrary to the spirit of science. It is in this light that you, as a science teacher, should view the topic of teacher-student interaction. A student-centred stance invariably:

* enhances interpersonal communication (students are more free to exchange views);

* enables students to accept sanctions far more readily (as when a teacher in a more or less consultory way asks what he should mete out for some undesirable behaviour).

WHAT ARE YOUR VIEWS ON TEACHER-STUDENT RELATIONSHIPS?

How exactly do you stand by way of what has been expounded thus far? No doubt through most of your school career you would have been brought up by a teacher-centred approach, and you see nothing wrong there. Perhaps the following activity will convince you to change.

Activity

The statements made for the activity are designed to help you review your position on certain issues. Answer according to whether you tend to agree or tend to disagree (in spite of any qualifications you may wish to make). Discuss with your peers.

Key : A - Agree
U - Undecided
D - Disagree

1. Science teachers should concern themselves with teaching science.

2. Discovery techniques may be effective with younger students but the older ones need to be taught.

3. The inquiry approach is a very time-consuming way of teaching.

4. Students learn more when they listen than when they talk.

5. Students should only speak when they are spoken to.

6. Not all science can be made interesting all the time.

7. Some children don't need motivating.

8. Don't despise punishment; it's the only way to get some students to learn.

9. For justice to be done, the punishment should fit the crime.

10. Punish hard and seldom, rather than lightly and often.

Well, are you an authoritarian teacher or a democratic teacher? According to research findings the following are some of the characteristics of each.

AUTHORITARIAN TEACHERS	DEMOCRATIC TEACHERS
Organise classes formally	Organise classes less formally
Do not encourage student activity or talk	Encourage student participation and respond to students' need
Foster competitiveness	Foster a cooperative spirit
Promote convergent thinking	Promote divergent thinking
Tend to be more punitive	Tend to be less punitive

WHAT TYPE OF TEACHERS DO STUDENTS PREFER?

It is to be expected that students, coming as they do from many different kinds of background, would vary widely in the teacher characteristics of which they most approve or disapprove. Yet despite the many likes and dislikes among students, studies (Morrison and McIntyre, 1969) show a high degree of unanimity. Students prefer teachers who are kind, friendly, cheerful, understanding to students' problems, allow plenty of student activity, and at the same time maintain order. They dislike teachers who use sarcasm and ridicule, are domineering and have favourites, who punish to secure discipline, fail to provide for the need of individual students and have disagreeable personality pecularities.

There it is. You have it now: what type of teachers the students prefer. But these are generalities. Of late the topic of cognitive styles have received a lot of attention in educational psychology research. Now, you may want to ask what cognitive styles have anything to do with teacher-student relationships. Briefly, cognitive styles have to do with the way in which a person operates. There are two main categories. Those who are:

field-independent : are people who tend to be more analytical in ways with which they think.

field-dependent : are people who are more global in their mental processing; this group of people also have better memory, are better mixers socially, and are people-oriented rather than test oriented.

As a rule language teachers are usually field-dependent, while science and mathematics teachers are more field-independent. What are the implications of this on classroom instruction? Let us again take a look at what research says.

Field-dependent students
- prefer to work in groups
- need more instruction
- prefer to take up social sciences
- prefer more guidance

Field-independent teachers
- prefer non-flexible approach to teaching
- believe in students' ability

Taking a cue from this, it is evident that the worst possible match is to put field-independent teachers to teach students who are field-dependent. If matching occurs, the learning styles of students and the teaching styles of the teacher are in unison. The expectations of the teacher are matched with expectations of the students, and bingo.

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