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Assisting teachers through curriculum change: teachers' use of support materials for teaching about smoking-related matters

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Teaching about smoking and related matters

Using a Science-Technology-Society approach, within the *Curriculum 2005* framework

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Why use this package?



The new South African curriculum, *Curriculum 2005*, requires teachers to change the their approach to teaching.

- This package explains the requirements of the new curriculum so that teachers can be sure about what the new curriculum expects them to do.
- The package introduces the *Science-Technology-Society* (STS) approach, and explains how this approach supports the *Curriculum 2005* requirements, when teaching science-related subjects.
- A range of lesson plans and other support materials are provided to help teachers teach about *smoking and related matters.*

Research findings and learning theory provide support for the approaches required by *Curriculum 2005*, and suggest good reasons for teachers to use this package. Some of these are summarised here.

Active mental engagement by the learners is essential for meaningful learning

Educational research has shown that scholars do not learn meaningfully by just being told the facts. Effective learning (real understanding of ideas, and the development of physical manipulative skills) requires the learners to incorporate information into their existing mental framework. This can be achieved by allowing learners to experience concrete activities, actually handle objects, observe or read resource materials, and then ensuring that they THINK about what they are doing and learning, and why. By doing this they literally "construct" their own knowledge.

Inquiry learning is a more effective way of learning

Research has shown that inquiry learning (where the teacher guides the learners to find out the answers for themselves) is an effective way of improving achievement and attitudes in biology. Students tend to understand the work better, remember information for longer, and enjoy their lessons more.

Learners should know how learning occurs

Research suggests that scholars who understand how learning occurs (metacognition), and who concentrate on using strategies which allow them to understand and learn more effectively, seem to learn better than those who don't know about how learning happens. Learners need to know exactly what the purpose is of each lesson and activity they do, and exactly what is expected of them. They also need to know "how to learn" effectively.

Teachers should evaluate the success of their lessons

It is widely believed that teachers who check whether their learners have mastered the outcomes of the lesson or not, and who use this information to modify and improve their teaching, make better teachers. By assessing their learners in this way teachers are actually evaluating their own success.

Learning biology should be fun

We are convinced that biology is the most exciting subject studied at school level. Teachers can reflect, by the way they conduct lessons, the wonders of nature and the excitement of discovering about it for one's self, so that learners enjoy each biology lesson and can't wait for the next one. Teachers need to see the importance of instilling in the learners an enthusiasm for biological investigations and a love of learning.

Regular assessment and feedback results in better learning

Research supports the view that learners who receive regular information on how they are doing (their strengths and weaknesses) and who do something about it, benefit in terms of learning. It is important that learners get constant feedback on whether they have achieved the outcomes of the lesson. If they have not, they should seek and accept help from the teacher.

Catering for diversity among learners

Allowance should be made for learners of different ability levels, pace of learning, interests, and cultural and religious beliefs. This will promote more favourable attitudes in the learners, and an enjoyment of learning, as well as making learning more relevant for all learners. Teachers should be encouraging those learners interested in biology to continue studying the subject at school, and perhaps later at tertiary level and in their careers.

Using an inquiry approach to teaching and learning

The lessons in this package have been designed to promote an inquiry approach to teaching and learning about smoking and related matters. This means that as much information as possible will come from sources other than the "teacher telling the learners the facts". In other words, the teacher should be a *facilitator of learning* rather than the source of all information. The aim of the worksheets is to guide the learners to discover information for themselves, based on the resources provided. The instructions in the worksheets will help learners to obtain information and THINK about it, so they understand the biology being taught.

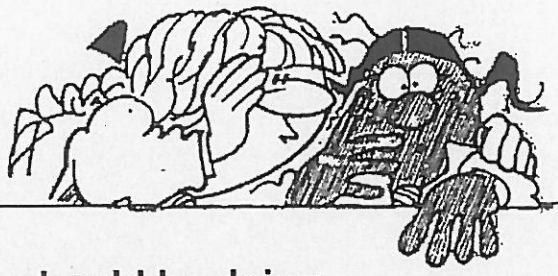
The INQUIRY approach contrasts with an ILLUSTRATIVE approach, where the teacher explains the work to the learners, and then provides them with practical activities to reinforce what they have been taught. Research has shown that this is a less effective way of teaching and learning.

The teacher as a facilitator (what the teacher must do)

The role of the teacher is to provide a suitable learning environment, and to guide and support the learners. A teacher who is a good facilitator meets the following responsibilities:

- plans suitable outcomes for all lessons (in this package lesson outcomes have been suggested);
- plans suitable activities for achieving the outcomes (this package provides a number of suggestions);
- provides the resources needed for learners to investigate matters and find out information for themselves;
- guides the learners so they know what to do, why they are doing it, and how to do it;
- points out, and addresses, problems and errors as they become apparent in class;
- assists learners who are not coping, or who need help;
- praises learners who are doing well;
- consolidates the lesson once the activities are finished (i.e. ensures that the learners have obtained all the information they need, and that the ideas the learners have developed are scientifically correct). If different groups have worked on different tasks, other learners need to know what they have found out. A good facilitator makes sure the ideas are shared by the whole class, and that the information is scientifically acceptable.





What the learners should be doing

The learners need to play an active part in the learning process. They must learn:

- to take responsibility for their own learning;
- to follow the teacher's instructions about independent work to be done outside of the formal lessons (either preparing for lessons, consolidating learning after lessons, or doing independent new tasks);
- to follow instructions in the worksheets, in order to complete the activities and answer the questions posed;
- to monitor their own progress by checking that they have mastered the outcomes of the lessons;
- approach the teacher for assistance if they need help.



FLEXIBILITY - it's all up to the teacher

Whilst we have recommended certain approaches, and request that teachers use the inquiry approach in the teaching of the topic of *'smoking and related matters'* it is up to the teacher to decide exactly how the lessons will be run. Teachers are better able to judge their classes and what their learners can cope with in a lesson. Although we have provided some suggestions for lessons, the teacher should decide which activities to do, which ones should be done in class and which at home, and how much should be tackled in one lesson. Some schools may not have timetabled double lessons for their junior biology classes, and as we have designed many of the activities for double lessons, teachers will have to cope with this problem and decide how they will divide the work.

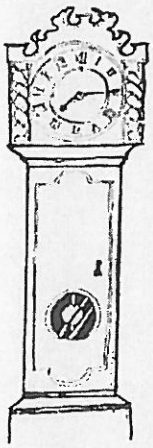
However, we recommend that you use the worksheets to do the teaching. Do NOT use the worksheets AFTER LEARNERS HAVE BEEN "TAUGHT THE FACTS". This destroys the whole purpose of the **inquiry approach**, and turns lesson into traditional **illustrative** ones. Lessons taught in an illustrative way have been shown to be less effective.

How to "make more time"

One of the challenges of "inquiry lessons" is that the process is very time-consuming. There is no question about it - inquiry lessons take more time than having a teacher just "explain the facts". Many teachers give this as a reason for not using inquiry methods in their classrooms. However, we believe so strongly in the effectiveness of this teaching approach, and the advantages that it gives the learners, that we feel teachers need to find ways of overcoming the challenges of lack of time, so that they can use inquiry methods in their classrooms. Here are some ideas which you can try.

Encourage learners to get to class as quickly as possible. This task will be far easier if your lessons are exciting and motivating, so learners just can't wait to get started. However, it will also require the teacher to carefully train the learners to be punctual.





Class time can be saved by getting learners to do more activities at home, although the teacher should not make unreasonable demands in this regard. This "homework" could involve

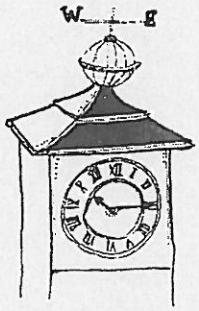
- PREPARATION for future lessons (e.g. reading over worksheets to be used in the next lesson, or advance reading on new topics to be covered in the next lesson);
- tasks which CONSOLIDATE work done in class (e.g. exercises which allow learners to revise work covered in class, or practice skills taught in that day's lesson). Revision tasks could include making their own summary notes of the lesson, or tasks which enrich or expand on work covered in class;
- new INDEPENDENT TASKS, which might cover work which will not be dealt with in class (e.g. finding information, conducting an investigation, doing a project).

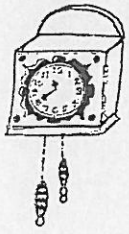
Remember that homework should not be a burdensome chore. Tasks should not be too big, and they should be structured as challenges which the learners will look forward to doing.

If learners are doing a worksheet-directed activity in class, much time can be saved by going over the introductory comments with the whole class. This not only settles the class down to work, but means that learners are not slowed down by having to read everything written in the worksheet.

In the worksheets in this package, the teacher can quickly explain the purpose and outcomes of the lesson, ensure the learners have all the requirements they need for doing the activity and completing the worksheet, and even give instructions for the first task. In speeding up the start of the lesson in this way the teachers must take care not to revert to "telling the learners the facts".

Once the learners start working, the different pace of different learners will make it tricky for the teacher to continue "speeding them up" as they progress through the worksheet. However, skilled teachers might be able to "chivvy them up" at intervals through the lesson.





Certain sections of work in the curriculum can be "taught" by means of carefully constructed independent reading assignments or projects, which learners can conduct outside of formal classroom time. This time-saving method is successfully used by many teachers in South Africa, even at primary school level. In this way time can be saved for teaching other sections in class using inquiry methods.

The advantages of using worksheets



- They "do the teaching" thus freeing teachers to monitor the progress of individual learners, and to give individual attention where it is needed.
- All explanations and instructions are in writing, so teachers do not have to constantly repeat themselves.
- Well-designed worksheets provide a well-structured record of work, so learners do not have to spend time copying down notes.
- They allow individual learners to proceed at their own pace. Exciting extension activities can be provided for fast learners, or those particularly interested in the topic. Care should be taken not to make fast workers do boring extra work!
- Because much of the information is provided on the worksheet, the teacher can spend less time checking that the learners have an accurate record of work.
- Worksheets can be designed to allow for some work to be completed at home.
- Well-designed worksheets will have been designed to make the learners THINK about what they are doing, so that learners are helped to "construct their own knowledge" and "meaningful learning" takes place.

The aims of the worksheets in this package

1. To allow the learners to see the relevance of biology in their everyday lives.
2. To stimulate interest and excitement in biological investigations, and to promote a positive attitude to learning biology.
3. To assist learners to master the important skills ***taught*** in the package.
4. To suggest activities with well-worded instructions and guidelines, for lessons investigating smoking and related matters.
5. To ensure the learners have a well-structured and accurate framework for their notes on the section of smoking and related matters.



Your own additional notes

Understanding the requirements of *Curriculum 2005*

A brief history of the new curriculum, *Curriculum 2005*

Curriculum 2005 was first introduced in South African schools in 1998. Although the requirements were a big shock to many teachers, many of the changes which teachers have been asked to make in their classroom are likely to lead to improved teaching and learning. It is therefore worth persevering with implementing many of the changes required by the new system.

However, a number of difficulties were experienced in the implementation process, and a review of the situation was therefore undertaken within two years of the implementation. The report of the review committee, released in 2000, revealed a number of problems in its implementation.

The review committee therefore recommended simplifying the curriculum requirements and the language (terminology) used in the policy documents, and also relaxing the time-frames for implementing the new curriculum. The revisions to the curriculum appeared in a policy document called the *"Revised National Curriculum Statement for Grades R - 9 (Schools)"*, intended to be implemented from 2006.

Although many changes have been made in the revised curriculum statement document, the underlying principles and fundamental requirements of what must happen in classrooms has remained largely unchanged. Theories about the effectiveness of learning, as well as research worldwide, have shown the value in making these changes.

The work of our research group

A group of biology staff and senior postgraduate students at the *University of the Witwatersrand* has been involved in research relating to the new curriculum. We have conducted research

i) to identify problems teachers have experienced in implementing the new curriculum,

ii) to find out what help they say they need,

iii) to investigate the quality of textbooks as support materials to help teachers change their practice, and

iv) to develop and evaluate support materials to assist them implement the new curriculum.

This package is the first draft of one such study.

An invitation to teachers

If you would like to collaborate with the researchers to trial and improve this package, please contact Thabo Khoali URGENTLY

Thabo@gecko.biol.wits.ac.za Tel: (011) 717-6420 (work)

Some problems identified during the research

Research conducted since *Curriculum 2005* was first introduced has revealed that many teachers have struggled to implement the new curriculum. There appear to be four main problems.

❶ ***I am unsure about exactly what the new curriculum requires me to do in the classroom.***





❷ ***I know the terms used in Curriculum 2005 policy documents, but I am not exactly sure about what the terms mean. What is "learner-centred" and what must a "facilitator" do?***

❸ The third problem is that some teachers have misconceptions about what the new curriculum requires. Some of the common misconceptions are

All learning must be done in groups.



All activities and tasks must be assessed.





Learners must find out everything for themselves. Teachers can't tell the learners anything.



"Activity-based lessons" means the same thing as "learner-centred lessons".

❹ The fourth problem is that many teachers lack ideas and have been asking for support materials such as lesson plans and worksheets.



I don't have any ideas for activities for my classes.

I have no support materials and don't know where to find any.



The requirements of *Curriculum 2005*

This section is intended to help teachers understand the new curriculum by briefly

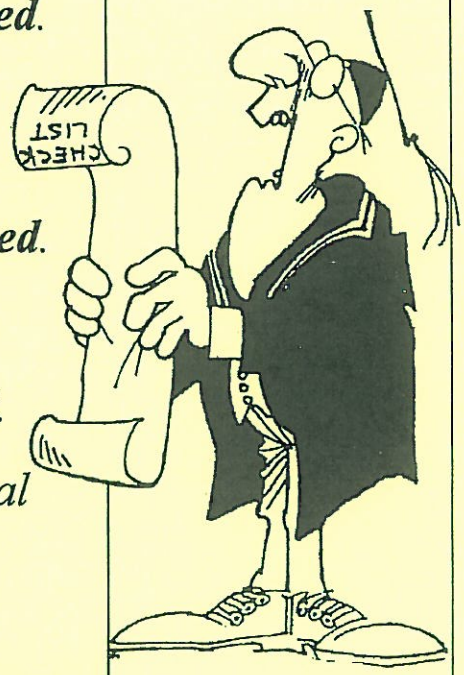
- outlining the nine basic requirements of the new curriculum, and
- spelling out what teachers need to do to fulfil each of the nine requirements.

Essentially the new curriculum has nine basic requirements, as shown in the following list. These requirements have been put together after an extensive review of the various policy documents which have appeared since 1997, none of which really clearly (or consistently) spells out what is required of teachers.

Because research since the implementation of the new curriculum has identified that many teachers do not understand these requirements, we have spelled out, in the following pages, exactly what teachers need to do to meet each of the requirements

The nine basic requirements of *Curriculum 2005*

1. *Education should be **outcomes-based**.*
2. *Teachers should be **facilitators of learning**.*
3. *Learning needs to be **learner-centred**.*
4. *Learning should be **activity-based**.*
5. *The **curriculum** should be **relevant**.*
6. ***Skills development** should be a focal part of the curriculum.*
7. ***Group work** should be promoted.*
8. ***Continuous assessment** should be used to foster learning.*
9. *Learning should be **integrated** across learning areas, at the junior levels.*





1. Education should be **outcomes-based**

Every South African teacher will probably be able to tell you that education must be outcomes-based, but what does this mean, and what are the implications for what teachers must do? Teacher need to understand the following points:

- Outcomes are *statements of what learners should be able to do AFTER a learning experience.*
- Outcomes are *not a list of activities to be done during the lesson*, but describe new things learners should be able to do AFTER the lesson.
- Outcomes *must include not only what learners must know, but also skills and attitudes they need to develop.*
- There are two main categories of outcomes spelled out in the curriculum documents:
  - The first category (which has no special name) spells out twelve outcomes (seven *critical outcomes* and five *developmental outcomes*) which describe what learners should be able to do once they have completed their schooling. These outcomes are intended to guide teachers from grade 1 to 12, across all learning areas.
  - The second category (formerly known as "specific outcomes" because they were specific to particular Learning Areas) are now called *learning outcomes* in the Revised National Curriculum Statement.

    The number of outcomes in this category has been reduced in the revised curriculum statement. For example, there used to be nine specific outcomes for the ***Natural Sciences*** learning area, but this has now been reduced to three learning outcomes.
- Teachers should formulate their own more detailed outcomes to help them plan specific lessons (we call these *lesson outcomes*).
- Teachers must plan their lessons to ensure that pre-stated outcomes are achieved by their learners (the broad *critical outcomes* and *developmental outcomes*, the *learning outcomes* specific to each learning area, and also their own *lesson outcomes*)

The critical and developmental outcomes

The critical outcomes aim to enable learners to:

1. identify and solve problems and make decisions using critical and creative thinking.
2. work effectively with others as members of a team, group, organisation, and community.
3. organise and manage themselves and their activities responsibly and effectively.
4. collect, analyse, organise and critically evaluate information.
5. communicate effectively using visual, symbolic and/or language skills in various modes.
6. use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
7. demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

The developmental outcomes aim to enable learners to

1. reflect on and explore a variety of strategies to learn more effectively.
2. participate as responsible citizens in the life of local, national and global communities.
3. be culturally and aesthetically sensitive across a range of social contexts.
4. explore education and career opportunities.
5. develop entrepreneurial opportunities.

(Revised National Curriculum Statement Grades R-9, 2002).

The learning outcomes for the Natural Sciences

- the learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.
- the learner will know and be able to interpret and apply scientific, technological and environmental knowledge.
- the learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.



2. The teacher should be a ***facilitator.***

Every South African teacher will probably be able to tell you that teachers should be facilitators of learning, but many are unsure about what this requires them to do. Some teachers have definite misconceptions about this, believing teachers cannot TELL learners anything, and that learners must be expected to find out everything for themselves. This is not correct.

The following points help to explain what "facilitation" involves:

- "Facilitation" simply means "to make easier" or "to assist the progress of", and it refers to *making learning easier.*
- Facilitating involves a *balance between the teacher explaining concepts and allowing learners to construct their own understanding.*
- In order to facilitate learning, teachers need to
  - *specifically plan lessons to achieve the outcomes.*
  - *be well prepared* in terms of their content knowledge and suitable pedagogical approaches to achieve the outcomes.
  - *provide the necessary resources* for meaningful learning to take place (not just leave the learners to think up answers from their experience or find things out for themselves).
  - *create a favourable environment which allows for meaningful learning* to happen (including disciplined behaviour from learners, a clean and tidy classroom, relevant current displays, etc.)
  - *monitor and deal with learners, as individuals or groups, as learning is happening* (identifying where problems exist and dealing with them, and recognising when help is needed and providing the necessary guidance).
- *Teachers needs to consolidate lessons to ensure* ***all*** *learners have covered* ***all required work,*** and that the concepts developed are those currently accepted by scientists to be "correct". This means that learners' ideas (developed as a result of their activities) need to be checked after each learning experience.



3. Lessons should be **learner-centred**

Whilst almost every teacher can tell you that lessons need to be learner-centred, few seem to understand what this means or what it requires them to do. Research has shown that many teachers think that "learner-centred lessons" and "activity-based lessons" mean the same thing - i.e. that learners should be involved in activities (doing things) in class. This is not true.

***Learner-centeredness* is focussed on recognising and catering for differences between learners. Learner-centred lessons require the following:**

☞ Teachers must *be aware that their learners are different.* Learners may differ in terms of different

- cultural backgrounds, beliefs and practices;
- home languages;
- preferred styles of learning;
- pace of learning;
- ways in which they can best demonstrate their achievements (e.g. showing their understanding of scientific concepts by drawing, by writing a report, by acting out a role-play, etc.).

☞ Teachers should *plan lessons to take into account these differences* (e.g. planning for more challenging activities for learners who are more interested or more able, planning activities based on pictures or other visual resources for visual learners, incorporating cultural beliefs and practices in lessons when relevant).

☞ Teachers must *actively accommodate differences* (in practice).

☞ Although it is true that learners should be at the heart of learning (actively engaged in the learning process) *"learner-centred" is not the same as "activity-based".*

☞ *Learners should be able to make some choices* about what and how they learn, if this can be done whilst still ensuring that all the necessary scientific ideas are learned.



4. Learning should be **activity-based.**

Almost every South African teacher will be able to tell you that learners should be actively involved in learning. However, many teachers do not really understand what this means. Researchers have found many science classrooms with the learners actively engaged in activities, but with no idea why they are doing the tasks. At the end of many activities the learners have built things, conducted experiments, acted out role-plays, or created posters - but have not learned any science.

Activity-based learning **is more than just mindlessly engaging in activities. Teachers need to understand the following important points, if they are to succeed in implementing activity-based learning:**

☞ The *activities must be meaningful* (purposeful) in order to achieve one or more of the planned outcomes (i.e. to acquire knowledge or understand some scientific concept, to master a necessary skill, or to develop an appropriate attitude).

☞ For meaningful learning (i.e. where learners understand the concepts) activities *must also engage the learners in mental activities.* The learners need to *think* about what they are doing and why they are doing it. They should *discuss their ideas with other learners,* or *write about what they are doing* (as this promotes understanding).

☞ *A variety of methods or strategies should be used* to actively engage learners in the learning process (e.g. by listening to or telling or writing stories, by watching or acting out plays, by listening to or composing or singing relevant songs, by working with pictures, by watching videos, by doing investigations or experiments, by watching demonstrations, by reading and answering questions, by carefully listening to the teacher explaining something). By doing these things learners are more likely to remain interested and on-task, and the different preferred learning styles of different learners are more likely to be accommodated. Classrooms will be more exciting and interesting places for the learners if teachers use a range of different activities.



5. The curriculum should be relevant.

Most South African teachers have believed for many years that lessons should be made relevant for the learners, but they are not always sure of the best way to do this, especially in classes where there is a wide variety of learners from very different backgrounds.

What exactly is meant by "relevant"? Relevance can refer to different things, and so lessons can be made relevant in different ways.

- Learning could be *relevant to South African context* (by basing lessons on South African situations or using South African examples).

- What is taught can be made relevant by *relating lessons to learners' real-life situations and experiences*.

- What is taught can be made relevant to learners by *linking lessons to what learners' already know (their prior knowledge*)

- Lessons can be made relevant by *focussing lessons on things which learners find interesting*, even if they did not have prior knowledge / experience of these things.

- Making learning relevant should be *more than just adding some relevant examples at the end of a learning episode* (i.e. avoid teaching the theory and then doing practical exercises to illustrate the theory - rather START lessons with a relevant problem or issue or story and then build the lesson around it).



6. ***Skills development*** *should be a focal part of the curriculum.*

Most teachers will be able to tell you that learners should be helped to develop skills. However, a common problem is that many teachers think that simply getting the learners to USE skills is the same as TEACHING skills. In fact skills need to be actively taught.

Teachers need to know the following, in order to develop skills in their learners:

- *Skills are competencies which can be learned, developed and improved with practice.*
- *Skills must be actively taught.* Developing skills is more than just getting learners to *use* the skills.
- *The skills to be developed should be stated as outcomes* in teachers' lesson preparations.
- Teachers must *target the skills in their lessons* by developing suitable activities which help learners understand what the skill to be developed is, why it is important, when it is appropriate to use the skill, and how the skill is done.
- The purpose of lessons /activities intended to develop skills should be *publically announced to the learners.*
- *On-going practice is needed* in order to perfect a skill.
- *Skills should*, at some stage, *be well integrated with content and not taught in a vacuum.*



7. *Group-work should be promoted.*

Perhaps one of the things South African teachers associate most with the new curriculum is that learners should work in groups. However, the research has shown a number of misconceptions relating to groupwork in the new curriculum.

- **Some teachers mistakenly believe that ALL LEARNING has to take place in the form of groupwork. This belief is incorrect.**
- **Some teachers believe that as long as the learners sit in groups they are doing group-work (although they are often each doing their own work, with no interaction).**
- **In many cases researchers have found learners sitting in groups and working on tasks which keep them actively engaged, but which do not result in learning of science concepts, skills or appropriate attitudes. Such tasks are meaningless.**

Teachers need to understand the following, to successfully implement groupwork.

☞ *Groupwork should "feature prominently"* in classroom practice, *but not all teaching and learning necessarily has to use this approach.*

☞ *Groupwork must involve purposeful, meaningful activities* to achieve outcomes (and should not just be done sitting in groups for the sake of working in groups).

☞ Groupwork is desirable because it *follows real-life situations where activities, decision-making and problem-solving at work and home often involve groups rather than individuals.*

☞ *All learners must participate actively in the shared (group) tasks.*

☞ *Groupwork can be used to develop social skills* (e.g. sharing, cooperation, listening, discussion).

☞ *The communication involved in groupwork helps learners to "construct knowledge" meaningfully (*by talking about what they believe and why, hearing about and debating different points of view, etc.).

☞ Successful groupwork will probably *require some extent of monitoring and guidance (facilitation) by the teacher.*



8. *Continuous assessment should be used to promote learning*

The term "continuous assessment" has become familiar to South African teachers. However, not everyone is sure what continuous assessment is, why it is necessary, or how it is best achieved. The research has shown that some teachers believe it means that assessment has to take place continuously (all the time) and that every lesson or even every activity has to be assessed. This is not true.

To understand and successfully implement continuous assessment teachers need to know the following:

- *Assessment should*, because of its central role in promoting learning, *happen regularly throughout the year,* and not just at the end of a section of work or the school term or year.
- Although a range of activities should be assessed, continuously through the year, *not every activity requires assessment,* and assessment does not have to be done every day.
- *Assessment is the mechanism to check whether intended outcomes have been achieved.* Teachers need to consciously check if learners have achieved the outcomes set.
- *Assessment should be used as a strategy to promote learning.* Assessment should provide feedback to learners about their strengths and weaknesses, so they can take action to improve their learning.
- *Assessment serves a number of different purposes* (e.g. diagnosing learners' weaknesses or misunderstood ideas, monitoring how learners are progressing, assessing whether outcomes have been achieved, etc.).
- *A range of different assessment methods and tools should be used during the year* so that learners with different skills and abilities and learning styles all get a chance to demonstrate their understanding, skills and attitudes in a way that suits them.



9. Lessons should be **integrated** across learning areas.

Most teachers will be able to tell you that the new curriculum requires that learning should be integrated across learning areas, especially at the General Education and Training (GET) level, but what, exactly, does this mean?

To understand and implement integrated lessons teachers should be aware of the following:

- Learning programmes should *incorporate knowledge from different learning areas.*

- Programme or phase organisers provide the mechanism for learning to be based on *themes which cross traditional subject boundaries.*

  (For example, if a programme is following up on the phase organiser [theme[of "proudly South African", biology lessons could deal with indigenous plants, animals, and medicines; geography lessons could cover local activities such as sheep farming in the Karoo or gold mining on the Witwatersrand; music lessons could incorporate the national anthem and typical songs / musical instruments of different cultural groups, language lessons could involve writing stories or poems about one's country; etc.)

- Activities in one learning area should *incorporate skills traditionally associated with different learning areas*

  (e.g. graphing skills, traditionally associated with maths, can also be used in geography and biology; mapping, traditionally taught in geography, can be used for the ecology section of biology).

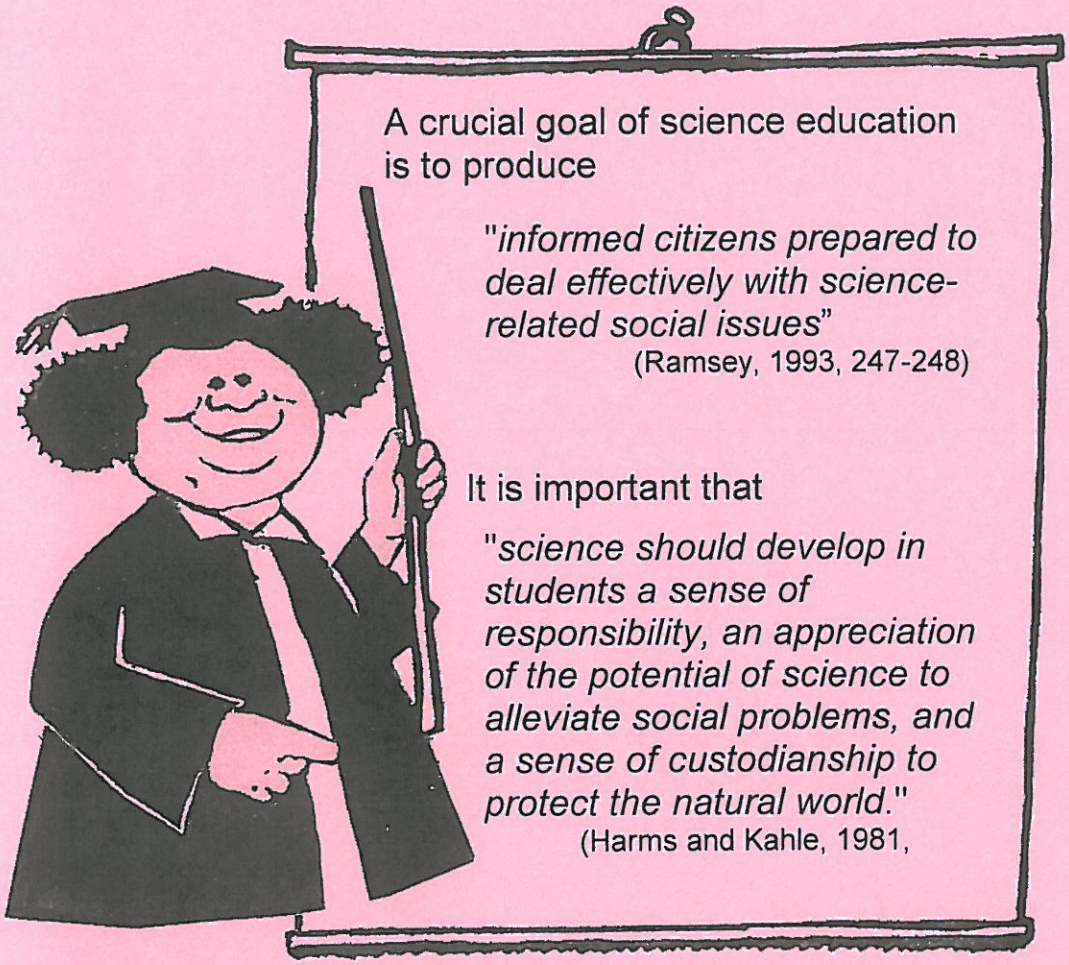


Your own additional notes

The *Science-Technology-Society* (STS) approach to teaching and learning

Why use the STS approach?

The Science-Technology-Society (STS) approach is a way of teaching which has become popular in the last few decades. It is based on the following assumptions.



These goals of the *STS approach* are very much in line with many of the critical and developmental outcomes of *Curriculum 2005*, in particular

Critical outcome 6

use science and technology effectively and critically, showing responsibility towards the environment and the health of others.

Developmental outcome 2

participate as responsible citizens in the life of local, national and global communities.

What is the STS approach?

The STS approach is usually used to plan a whole section of work, which will be centred around some real, relevant, current social problem or issue.

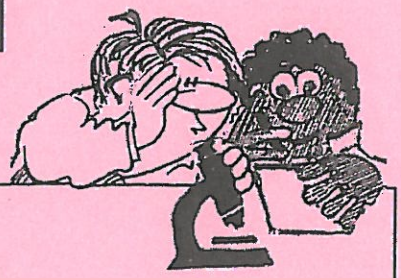


The teacher plans and then facilitates lessons which allow learners to develop the necessary skills they will need to investigate and discover more about the problem.

As the learners investigate they will find out more about the scientific knowledge they need to understand the issue. This means the inquiry approach is being used in the teaching.

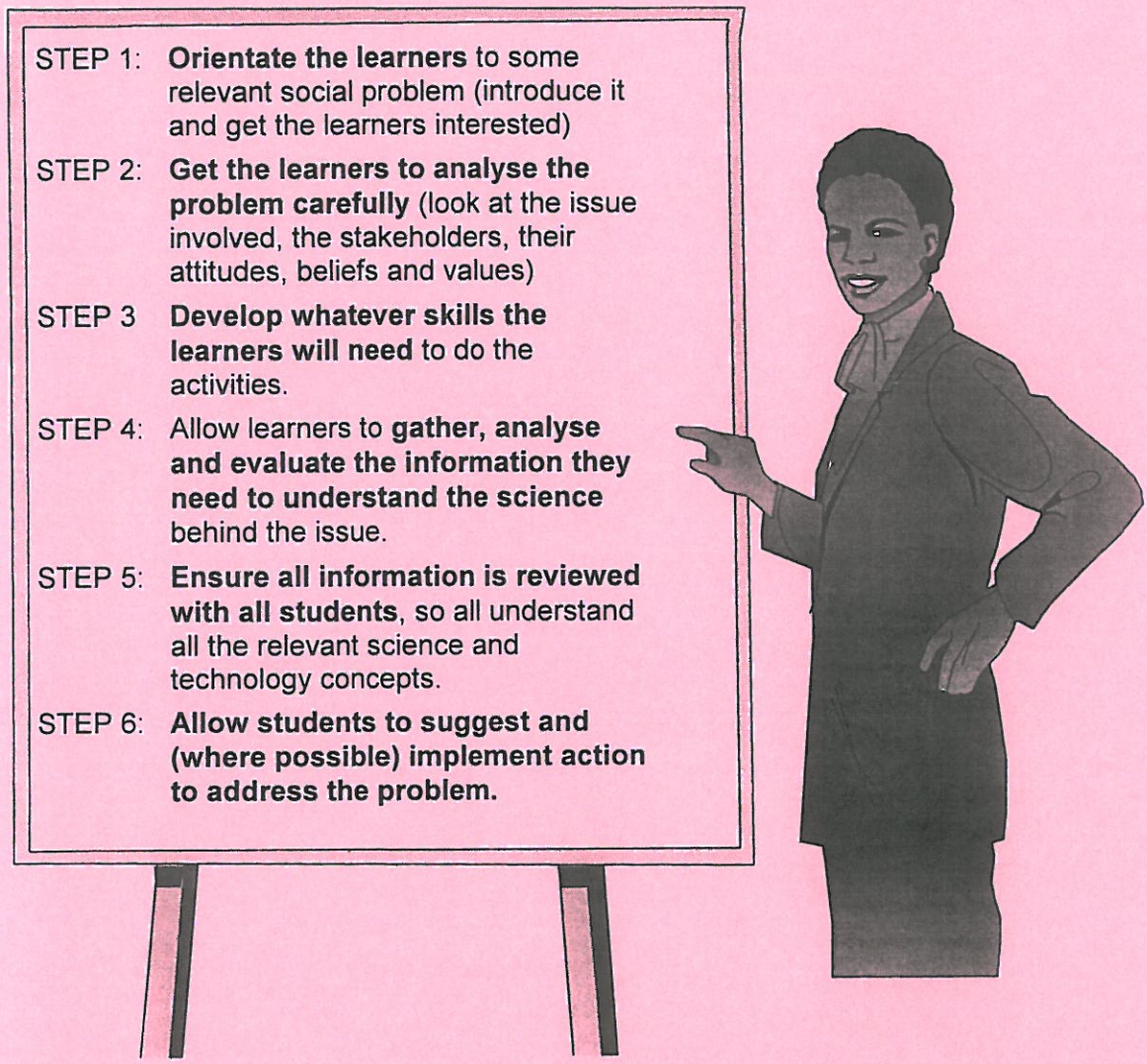
As part of their investigations learners will be given opportunities to evaluate the issue and propose possible solutions or take responsible action to try to solve the problem.

The compatibility of the *STS approach* with *Curriculum 2005*



- The content covered is ***relevant*** to the learners.
- ***Skills development*** is an important aspect of the teaching and learning process.
- Lessons are ***activity-based***, with hands-on and minds-on activities.
- The ***teacher acts as a facilitator***, planning lessons to meet important outcomes, supplying the necessary resource materials, and assisting learners to learn for themselves.
- Lessons can be made ***learner-centred***, by allowing learners to investigate aspects of the topic which interest them, as long as all the necessary aspects are dealt with by the class.
- The learners are usually ***working as teams*** on small investigative tasks, often with different teams investigating different aspects of the problem.

A six-step approach is often used in STS lessons



It can be seen that this approach will help develop several of the other critical outcomes not already mentioned:

Critical outcome 2: identify and solve problems by using creative and critical thinking.

Critical outcome 3: organise and manage activities responsibly and effectively.

Critical outcome 4: work effectively with others in a team, group, organization, and community.

Critical outcome 5: collect, analyse, organise and critically evaluate information.

Some useful references about the STS approach

Ajeyalemi, D. (1992). The status of STS in Africa. In Yager R.(Ed) ***The status of Science-Technology-Society reform efforts around the world.*** ICASE Yearbook.

Ramsey, J. (1993). The science education reform movement: Implications for social responsibility. ***Science Education,*** 77(2):235-25.

Trowbridge, L. and Bybee, R. (1990) ***Becoming a secondary school science teacher.*** Chapter 24: Science-Technology-Society: A vision for science teachers. p.417-435.

Watts, M. (1997). 'Events-centred-learning': an approach to teaching science, technology and societal issues in two countries. ***International Journal of Science Education,*** 19(3):341-351.

Yager, R., Tamir, P and Huang, D. (1992). An STS approach to human biology instruction affects achievement and attitudes of elementary science majors. ***The American Biology Teacher,*** 54(6): 349-355

Yager, T, Tamir, P. and Kellerman, L. (1994). Success with STS in life science classrooms, Grades 4 - 12. ***The American Biology Teacher,*** 56(5): 268-272.



The teaching of skills

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(the master copies of worksheets may be photocopied by South African biology teachers for use in their lessons)

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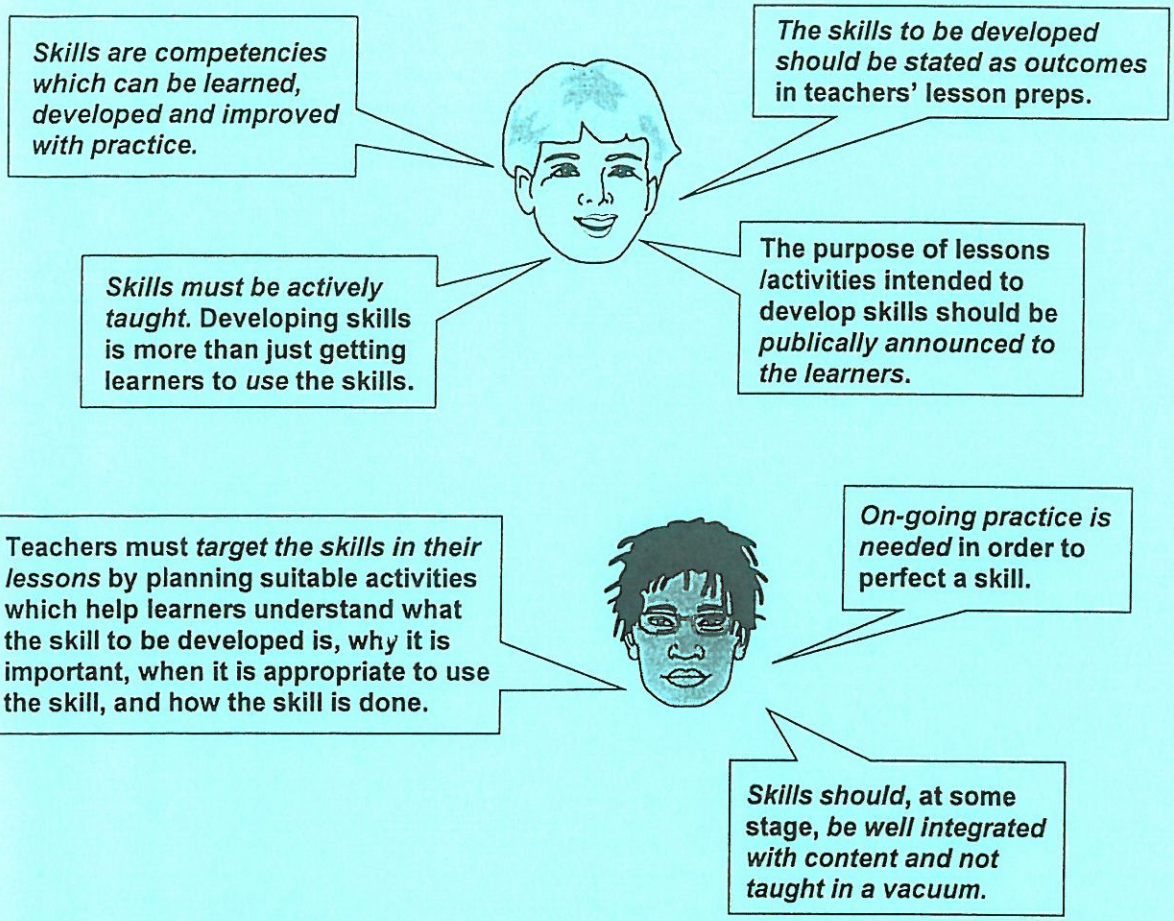
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Teaching skills - the teacher's role

As pointed out on p. 17 (in the section on "Understanding the requirements of Curriculum 2005") the development of skills in the learners is now a focal goal of the new curriculum. As discussed in that section, this has crucial implications for teachers, which are reiterated below.



Why teach skills in biology?

Curriculum 2005 places a strong focus on the development of skills in the new curriculum. The first question to think about is whether we NEED to teach skills in biology. Here are some good reasons for teaching skills.

- ***Coping with the information overload***: We are living in the *information age*. Things are being discovered and invented every day. When our mothers were at school nobody knew about DNA and its vital role in coding genetic information, and AIDS had never been heard of. Due to the "knowledge explosion" there is now so much information in any particular subject area (e.g. biology) that it no longer makes sense to have a curriculum which focuses on the memorization of facts. The "facts" are changing so fast that what children are taught at school is likely to be out of date by the time they matriculate. The invention of new technologies has resulted in amazing research in biology, and scientists' knowledge of life and living things is expanding every day. If adults relied on the "facts" they learned at school

their knowledge would soon be inadequate (incomplete and out of date). It would make more sense if the school curriculum *taught people to keep up to date with information by finding out new information for themselves*. Finding information is an ability or skill which people need to be taught. In fact, to find information requires a large number of other specific skills.

- ***Becoming more capable people:*** A second reason for learning skills is that they have intrinsic value. It is useful to acquire certain skills, for example being able to *use a computer*, being able to *communicate effectively* with other people, or being able to *work together as part of a team*. Skills such as these are important in everyday life. Furthermore, you can increase your chances in the "job market" by acquiring skills such as these, which will make people want to employ you. In biology many of these skills are related to doing laboratory work.

- ***Teaching skills is an important international trend:*** The teaching of skills is a worldwide trend, and South Africa should not fall behind if we are to survive as a nation. The new school curriculum, *Curriculum 2005*, requires the development of skills as well as the acquisition of knowledge. If you look at the seven critical outcomes and five developmental outcomes (the 12 outcomes which describe the sort of citizen the education system is trying to produce) you will see that many of them are worded as skills which learners need to develop. As a teacher you are now *required* to teach skills.

Which of the outcomes involve the development of skills?

- Carefully read the seven critical outcomes and five developmental outcomes listed below.
- Put a tick next to those which involve the learning of skills.

Hint: *Remember that a skill always involves the ability to do something.*

The critical outcomes aim to enable learners to:

1. identify and solve problems and make decisions using critical and creative thinking.
2. work effectively with others as members of a team, group, organization, and community
3. organise and manage themselves and their activities responsibly and effectively.
4. collect, analyse, organise and critically evaluate information.
5. communicate effectively using visual, symbolic and/or language skills.
6. use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
7. Demonstrate an understanding of the world as a set of related systems, by recognising that problem solving contexts do not exist in isolation.

The developmental outcomes aim to enable learners to

8. reflect on and explore a variety of strategies to learn more effectively.
9. participate as responsible citizens in the life of local, national and global communities.
10. be culturally and aesthetically sensitive across a range of social contexts.
11. explore education and career opportunities.
12. develop business opportunities.

(Revised National Curriculum Statement Grades R-9, 2002).

In fact the wording "*enable learners to ...*" implies that ALL of these are skills to be taught, as they describe what the learners should be able to DO. Many of them are obviously skills (e.g. 1-5 and 8), but others are less obvious (e.g. "*Demonstrate an understand of the world as a set of related systems*" is worded as knowledge and not a skill).

What skills should we teach in biology?

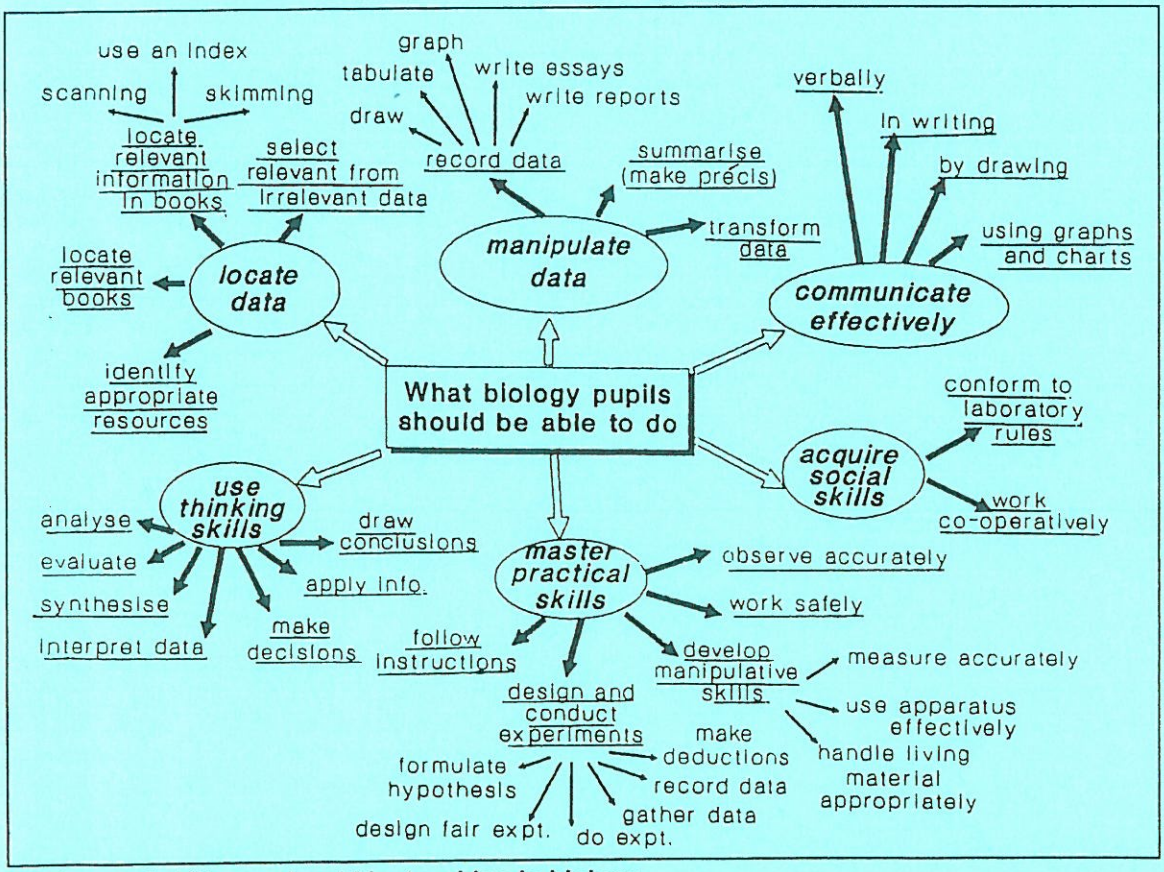
In addition to targeting skills which are listed in the critical and developmental outcomes, teachers also need to target skills specifically listed as learning outcomes in the natural sciences. The first of these three learning outcomes targets skills, namely

Learning outcome 1 (Natural Sciences, GET level)

> *"the learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts."*

However, the outcome is worded very vaguely, and does not really help teachers to see what skills they should be developing. Natural science teachers need to be much more specific about the skills they want to target. They need to write these skills into their lesson plans in the form of their own more detailed "lesson outcomes" which they should be setting for each specific lesson they plan.

Here, in the form of a mindmap for teachers who are "visual thinkers", are some ideas about skills biology teachers could target. For those teachers who prefer their information in a more traditional text-based format, the points are presented as a bullet list on the next page.



Mindmap of skills we should be teaching in biology

Read mindmaps from the inside outwards, as the main ideas are usually in the middle, and get sub-divided into categories and sub-categories as you read outwards.

Some of the skills biology teachers should be teaching their learners

Locate data
- Identify appropriate resources containing the data wanted
- Locate relevant data in books
  - use an index
  - scan
  - skim
- Select relevant information

Manipulate data
- Record data
  - draw
  - tabulate
  - graph
  - write essays
  - write reports
- Summarise information (make a précis)
- Transform data

Communicate effectively
- Verbally
- In writing
- By drawing
- Using graphs and charts

Acquire social skills
- Conform to laboratory rules
- Work co-operatively with others

Master practical skills
- Follow instructions
- Design and conduct experiments
  - formulate hypotheses
  - design fair experiments
  - conduct (perform) experiments
  - gather data
  - record data in appropriate formats
  - make deductions (from the results)
- Develop manipulative skills
  - measure accurately
  - use apparatus effectively
  - handle live specimens appropriately
- Work safely
- Observe accurately

Use thinking skills
- Analyse
- Evaluate
- Synthesise
- Interpret data
- Make decisions
- Apply information
- Draw conclusions



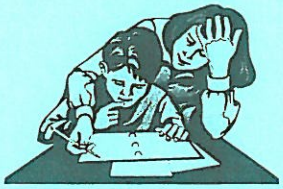
Think about the last year of biology teaching you did, and then answer the following questions.

1. Using the mind-map or the hierarchical list of skills as a checklist, put a tick next to those skills which you have, during your last year of teaching, expected your students **to be able to use**.
2. Did you specifically **teach** your students any skills last year (how to do them) or did you just expect them to use the skills?
3. If you have taught any skills, make a list of those you HAVE taught, and then make a note of those which biology students need, but which you have never specifically taught. You need to target these skills in your teaching.

How does one go about teaching a skill?

Here is some general advice about teaching a skill, followed by a sample activity which can be used to teach biology scholars *the skill of drawing*.

IMPORTANT STEPS TO FOLLOW WHEN TEACHING A SKILL



Generally-speaking the essential steps to follow when teaching a skill are:

- pre-test
- make the purpose of the activity clear
- teach WHAT
- teach WHY
- teach HOW
- teach WHEN
- provide opportunity for practice
- assess (post-test) and give feedback

You may not always teach these things in this order.

Each step is described in more detail below (p. 32-33). Then they have been applied in the activity to teach the skill of drawing (described on pages 33-36). Then, on p. 36, a table is provided which summarises these general rules for teaching skills, and how they were applied when teaching drawing skills.

STEP 1: Pre-test the learners' skills

It is often a good idea to find out, before teaching a skill, which learners already have the skill, which don't, and how good the different learners are at the skill. Teachers may not be sure how good the learners' skills already are, especially now that learners are meant to have their skills developed from grade 1.

Pre-testing can be done by using a "diagnostic task". This is an assessment activity given to the class before they are taught a skill, with the purpose of identifying the strengths and weaknesses of each learner, regarding that particular skill. With this information teachers will be able to plan more appropriate lessons. Should they teach the whole class, and at what level? Are there just a few learners needing help? How much help? What specific help?

STEP 2: Make teaching the skill an explicit goal of the lesson

Both teachers and learners need to focus on the purpose of the lesson, and know that the aim is to actually teach and develop the particular skill being targeted. Research shows that the teaching will then be more effective.

Very few teachers will actually TEACH skills unless they purposely set out to do so (many may make their learners USE the skill, without ever TEACHING them how to do this). Teachers must intend to teach the skill (it should be specified in their lesson plan as one of the goals or aims of the lesson, and also as one of the outcomes they want the learners to have achieved by the end of the lesson or series of lessons).

Learners must know that they are being taught a skill - i.e know that it is the purpose of the lesson / activity they will be doing.

NB: It is important to note that Steps 3-6 need not necessarily be done in this order.

STEP 3: Teaching WHAT the skill is

At some stage during the teaching the teacher needs to make it very clear to the learners what the skill is. For example, it is no good teaching about "the skill of scanning" if learners do not know what scanning is. Even if skills SOUND self-explanatory, they are not always clear. For example "graphing" and "working in groups" sound like common sense, but what exactly do they involve? It is the teacher's job to make this clear to the learners.

STEP 4: Teaching WHY the skill is useful and important

Often learners will not see the need for them to learn a skill. If you can make them see how it is relevant to THEM, and will benefit them, they are more likely to focus on developing the skill.

STEP 5: Teaching WHEN the skill is important

Certain skills are often needed at particular times, and this needs to be pointed out. For example, the skill of *tabulating*, while a very good way of summarising information in a logical way so it can be seen at a glance, is ***not always*** a good way to summarise information. It is only really useful when there are items which have certain features in common which can be compared so that differences can be noted.

STEP 6: Teaching HOW the skill is done

It is very important not just to do a "chalk-and-talk" lesson in which you give the learners a set of rules to follow. Research has shown that this does not really help learners very much. It is much more effective to get them DOING the skill, and to get them to THINK about what they are doing, and why. The next exercise on drawing skills will show how this can be done.

STEP 7: Provide opportunity to practice and improve the skill

Because a skill is an ability, you will never be able to teach it in a single lesson. In the same way that runners, dancers and musicians need to practice their skills, so do the learners with the skills you will teach them. With regular use and practice they will get better at doing the skills.

STEP 8: Post-test (assess) and provide feedback

Assessment will allow the teacher to evaluate how successful their teaching of the skill has been, and whether they need to do more work on helping the learners.

More importantly, assessment and feedback are a vital part of the learning process. The learners need to know (i) how well they are performing the skill, (ii) what they are doing right, (iii) where they are going wrong, and (iv) how they can improve. This means that assessment (whether self-assessment or assessment by the teacher) is vitally important. Give feedback to the learners (whether by written comments to individuals, or whole class discussions) so they know how they are coping, and what they need to do to improve.

Sample exercise - teaching the skill of *drawing*

Here is a sample activity in which the general advice about how to teach a skill has been applied to teach biology scholars the skill of drawing. The ability to draw accurately is closely associated with the skill of good observation.

Teaching the skill of drawing (Sanders, 1986)

What you will need

a watch which shows seconds (or a friend to time you).
a piece of paper
a pencil
a pen

Getting started

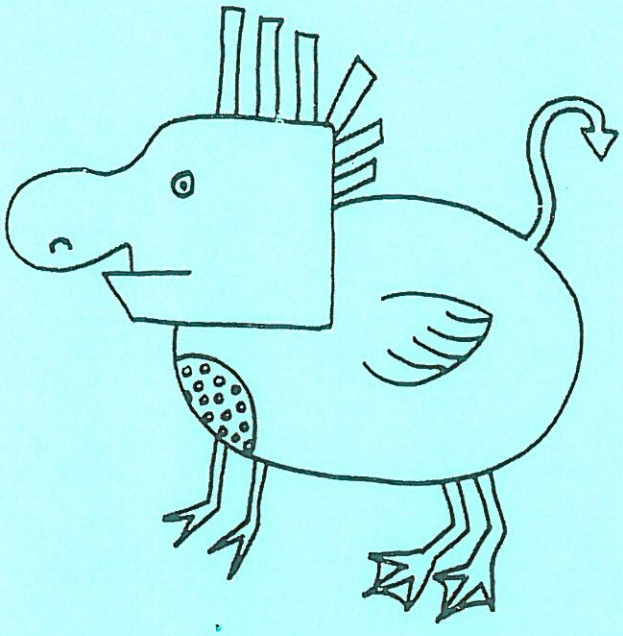
This lesson should be taught after the students have done some practical work in which they have had to draw a biological specimen. This activity serves the purpose of the ***diagnostic pre-test.***

Their drawings are often poor and they make comments like "*but miss, I am not an artist*". Explain to them the importance of being able to make accurate records by drawing in biology. Tell them that this exercise will quickly teach them to be "good artists" and do better in biology (***teaching the WHY***).

The lesson should continue as follows. *Do this task for yourself as you read.*

Instructions

- You are going to be shown a diagram of an imaginary animal, for just 20 seconds. During this time all you must do is examine it as carefully and thoroughly as possible, so that later you can draw it. You cannot have a pen or pencil in your hand during these 20 seconds.
- Are you ready? Remember, you have just 20 seconds to look at the animal in the picture - then you must cover the picture. Start the clock (or ask your friend who is timing you) as soon as you turn the page (the picture is on the next page).
- Now that you have looked carefully for just 20 seconds, cover the picture and try to draw it from memory (no cheating now, or you won't see the point of this exercise). Good drawers need also to be good observers.
- When your drawing is finished, uncover the picture and look carefully to see whether your diagram looks like the original. Take a different colour pen or pencil and change the drawing to make it look more like the original. Do not rub out your original lines. You need to see where you went wrong, and how you can do better.
- At this stage of the lesson the teacher should use a whole-group discussion to get the students to say what the things are that one needs to consider if one wants a drawing to look like the original (i.e. what aspects must you think about when you are trying to do an accurate drawing?) The teacher should list the relevant points on the board as the students supply them during the discussion, so that there is a visual summary of four important factors to consider if you want your drawing to be accurate (see table on p. 35). Note. the teacher should not tell the students (chalk-and-talk approach). The teacher should provide the necessary learning task which allows them to find out the information for themselves (inquiry learning). In doing this the teacher will act as a "facilitator" for learning (***teaching the HOW of the skill of drawing***)
- Now you try this, by making a list of things you would need to consider if you want a drawing to be an accurate representation of the original object you are drawing. It might help you to chat to a friend about this.



Blue-breasted schlemptygump

Blue-breasted schlemptygump drawing task (from Sanders, 1986)

You need to consider four things, if you want to do an accurate drawing.	
Shape	For example, look at • the shape of the tail (like a back-to-front question mark), • the very angular shape of the head, with its jutting-out jaw, • the bulbous nose, • the egg-shaped body. If you draw the *shape* incorrectly your drawing will not look like the original.
Proportion	This refers to relative size. Look at the following, for example • the height of the body relative to the length (like an egg), • the size of the head relative to the size of the body (most people draw it much too small, but it is about half as big as the body), • the length of the front legs compared to the back legs (I think this animal would only be comfortable living on a mountain, and would always have to face uphill). If you get the *proportion* incorrect your drawing will not look like the original.
Position	Position is very important. Look, for example, at • where the tail comes out of the body (not right at the back), • the position of the wing on the body, • the position of the front legs relative to the spotted breast. If you get the *positions* wrong your drawing will not look like the original.
Number	Sometimes the number of certain structures is important. For example, look at • the number of feathers on the top of the head, and at the back, • the number of toes on each foot. If you get the *number* wrong your drawing may not look like the original.

Table showing general rules for teaching skills, and their application in the "drawing" lesson

Step	General rule	How this rule was applied in the drawing task
Pre-test	Start by diagnosing students' mastery of the skill before it is taught, to identify the nature and extent of any problems and weaknesses.	Getting the students to do a drawing was, in effect, giving them a diagnostic test. The teacher can see how well each student coped, identify the nature of the problems in the class and the extent of the problems. One usually finds that the whole class needs to be taught drawing skills.
Make the purpose of the activity clear	Make the purpose of the activity clear to learners so they know what they are doing and why, so they have goals to aim for.	The purpose of the activity was made clear - that it was to help them to draw biological specimens more accurately - an important skill needed by biologists..
Teach WHAT	They need to know what the skill is they are learning.	Often this is best understood by participating in an activity, not by being given a definition of what the skill means. They were told the activity was about developing drawing skills, but the activity helped them understand what this meant, and the importance of also being a good observer if you want to draw well.
Teach WHY	Help them to understand why the skill is an important one for them to master, so they see the lesson as relevant.	The importance of the skill of drawing in biology was pointed out - that biologists need to be able to make accurate visual records. One way biologists do this is by drawing things. Biology students also need to develop this skill.
Teach HOW	Provide suitable activities which allow them to see how the skill is done, so they develop the skill. Preferably use inquiry methods which allow them to develop understanding, so they don't just listen to you telling them what to do (a recipe-type approach).	Students were helped to articulate what they could do to become better artists. This was not done by giving them a set of rules - they were given an activity, and then (by questioning) led to come up with the important points. Note that the discussion activity afterwards works best when the whole class participates, so the learners can learn from each other.
Teach WHEN	Explain when it is appropriate to use the skill.	Explain to them how important it is to biologists to have an accurate record of their findings, so they can communicate information effectively to others. So when students are doing **biological** drawings it is important to draw accurately (they can be more creative in **art**).
Practice	Provide plenty of follow-up practice activities to allow them to practice and perfect the skill, so it becomes second nature to them and they do not have to think about what they are doing.	Spend the next few weeks giving them activities which allowed them to practice the skill of drawing.
Assess and give feedback	Assess the students to see how well they have mastered the skill. Give them appropriate feedback so they can improve.	Use a range of ways to assess students' mastery of drawing, including self-assessed, peer-assessed, and teacher-assessed tasks. Provide feedback on ways to improve.
Post-test	Once you feel the skill has been taught, test to see whether students have learned it.	A final drawing task should be used to see how well the teacher has succeeded, and to decide whether some students needed further teaching.

The skills learners will need for this module

The following skills are needed for this section on smoking. If you have not already taught the learners these skills, you will need to do so. In the following section we have included some ideas and worksheets which you could incorporate in your lessons.

- Working in groups
- Making a presentation
- Recording data in the form of graphs
- Conducting a survey

  Designing a questionnaire

  Conducting an interview
- Designing a fair test
- Brainstorming

The following pages contain a series of information sheets or activity sheets which can be used in lessons in which you wish to teach or develop skills which the learners will need to use in the suggested lessons in this package about smoking and related matters.

NOTE: ***If you are teaching the skills for the first time you will need to design a lesson, using the guidelines for "teaching a skill". Remember that simply handing out some guidelines about the skill is not an effective way of teaching a skill.***

Working in groups

Some of the benefits of groupwork

- ***Real life involves working WITH people:*** In real life people seldom work in isolation:
  - At home people are supported by, and work within, the family group. They need to consider the feelings and needs of others, and they get support and help from their family members.
  - At school there are the feelings and needs of other scholars (and the teachers) to consider. Again, learners can get help and support from their peers and their teachers.
  - At work people often work as part of a team, and have others whose needs and feelings they need to consider, and whose help they should be able to count on.

- ***Sharing and support:*** Working in groups means you can share the work-load, share ideas, and get moral and physical support from others. Problems are more easily solved when many brains are working on the problem, and physical work is lighter when many hands take on the task.

- ***Discussion helps build understanding:*** At school, where students are trying to learn science concepts, discussing the ideas in groups allows learners to think things through, and make sense of the science. It helps them "construct" (build) meaning. EFFECTIVE groupwork is therefore a vital tool in the learning of science.

Some of the risks of groupwork at school

There are a number of the risks associated with doing groupwork at school:

- ***Sitting in groups does not always mean groupwork is happening:*** The teacher needs to make sure that the group tasks do actually involve the learners working together as a team. It is no good simply sitting in a group if every child is doing their own thing.

- ***Not all groupwork involves meaningful tasks:*** Science teachers need to ensure that the tasks set for groups are not simply activities to keep them busy, but that they make an active and positive contribution to the learning of science (content; skills; and beliefs, values and attitudes).

- ***Off-task behaviours occur:*** Social interactions mean that learners may be distracted by personal interactions not associate with the task, so that while they look active (and may be discussing things) they may not be working on the task set.

- ***Inter-personal problems may occur:*** Sometimes personal interactions in a group may not be working effectively. Some children try to dominate the ideas. Others are shy and withdrawn, and do not become involved. Some children are "doers" and like to do the work, while others like to get away with not doing anything, yet benefiting from the group rewards. Part of learning to do groupwork means mastering the social interactions which need to occur between members of the team.

What is co-operative groupwork?

Many teachers use the term "co-operative groupwork" when referring to any type of groupwork, simply because the learners are in groups and are assumed to be co-operating. In fact, co-operative groupwork is a special kind of groupwork which uses special strategies to ensure that learners DO co-operate. These startegies ensure that they increase their social groupwork skills, and take responsibility for their own learning. In doing so, members of the group learn together.

There are five crucial elements to co-operative groupwork:

- ***Face-to-face interaction:*** Clearly, to work in groups means people need to be together. Face-to-face interactions are necessary - for people to share beliefs, ideas and feelings; discuss; clarify ideas; debate issues; and propose strategies and solutions.
- ***Positive interdependence:*** All members of a group must feel like team members, working towards a common goal. They MUST depend on each other. For the GROUP to succeed every INDIVIDUAL must succeed.
- ***Individual accountability:*** Learners must take responsibility for their own learning, and play their part, if they and the group are to succeed.
- ***Social skills:*** Co-operative groupwork cannot succeed unless certain social skills are developed and used. Many of these will not be taught when traditional groupwork is taught. These include skills such as encouraging others, listening to what others have to say, clarifying what you mean, asking questions, taking turns, and playing your part. There needs to be decision-making, trust, conflict management and leadership.
- ***Group evaluations:*** Group members need to be aware of what they are doing and why. They should evaluate their own work to see how well they are doing as a group, and where they can do better. They need to act on this information, to improve the work of the group as a whole.

Strategies for achieving positive interdependence

Certain techniques can be used in order to ensure that there is *positive interdependence* (in other words, that the group can only succeed if everyone pulls their weight). For example, one could make sure that the whole group suffers if not all members participate, or that if they DO all contribute, the whole group is rewarded. Because the group has a common goal, they can achieve it only if everyone in the group co-operates. Strategies used to ensure co-operation include:

- ***GOAL positive interdependence:*** Team members need to be made aware that they do have a shared common goal, and that the team will fail unless everyone plays their part.

This can be encouraged by the teacher if:

- each learner has to do one part of the task, and all parts are essential for the final result;
- one product is required from the group;
- if individual products have to be submitted, they will only be accepted by the teacher when every individual has submitted their work. If one person from the group does not do his/her individual work, then the teacher will not accept the assignments of the other group members.

- ***INCENTIVE positive interdependence:*** If all group members co-operate to help the group achieve its goal, the team and all its members are rewarded in some way. This could be bonus marks, time on the classroom computer, receiving public praise or honourable mention on an honours list, etc. Try to ensure that the rewards are learning orientated (i.e. beneficial in terms of learning) rather than using rewards such as sweets.

- ***RESOURCE positive interdependence:*** If the group is given only one set of the required resources (rather than each student getting them) the group will HAVE to work together for individuals to ensure they complete the task. An example of this is the jigsaw method described later).

- ***ROLE positive interdependence:*** If every person in the group is assigned a specific role, and all are important in contributing to the group's success, positive interdependence can be promoted. Only allocate meaningful roles, which may change according to what the actual task is. Examples of roles are: recorder (scribe), data-collector, reader, time-keeper, noise monitor, encourager, project manager, coach.

- ***SEQUENCE positive interdependence:*** Divide the overall task into sub-tasks (one to be done by each group member), which have to be performed in a specific sequence. This ensures the overall task cannot progress unless each person does their specific job.

- ***IDENTITY positive interdependence:*** By bonding together and establishing a group identity, group members can be encouraged to work together co-operatively. This can be promoted by having a team name, symbol, slogan, song, signal etc. The group develops a sense of pride.

- ***ENVIRONMENT positive interdependence:*** Co-operation can be promoted if the group has a special physical meeting place, or a specific lab bench, etc.

Specific methods to promote cooperation

- ***Contracts:*** Group members could discuss their commitment to the group, and sign contracts to show their willingness to co-operate. Infringements could be dealt with (in a reasonable manner) within the group

- ***The jig-saw method:*** Each person in the group becomes an expert on one specific topic (e.g. by reading up on it from a resource provided by the teacher, or by independent research at home). The "experts" then teach what they have learned to others in their group, so that by the end of the lesson all group members have dealt with all the work.

- ***Mark allocations:*** Members of the group assess the contribution of each team member, and allocate a mark which becomes part of the mark that each individual gets given by the teacher. Members who do not contribute to the work get zero.

- ***Group challenges***: Groups set some quiz questions, which they pass to other groups who have to answer them. This is done in the form of a competition.

- ***Teacher quizzes:*** Each team member is given a number (e.g. 1 to 4). The group co-operates to learn some work, coaching each other. Instead of the teacher asking for a volunteer from the group to answer, the teacher calls a number. If that individual cannot answer, the group does not earn their point. This ensures the group members co-operate to learn the information.

- ***Peer coaching:*** During the lesson the teacher can ask pairs to explain to each other a concept just taught, or to give new examples. This helps promote co-operation amongst members of the group. People in the pair need to reverse roles every now and then.

- ***Think-share-listen-create:*** Individual members of the group first think of their own ideas, then share these with the group and listen to the ideas of others. Once everyone has had a say and heard all the ideas, the group selects the best and goes forward with it.

- ***Round-tables:*** With this strategy the teacher goes round a particular group, asking a series of revision questions. The group only gets a chance to continue answering questions if no-one in the group misses a correct answer. Once someone misses, the teacher moves on to the next group. This strategy makes individuals try harder.

The teacher's crucial facilitation role

Teachers should note that an enormous amount of facilitation on the part of the teacher will be needed to ensure that the groupwork done in the classroom is meaningful and effective.

- ***Planning:*** As for all lessons, the teacher needs to be very well prepared.
  - Outcomes to be achieved must be reviewed (*critical outcomes, developmental outcomes* and *learning outcomes* from the *Curriculum 2005* policy documents). Suitable, more-detailed *lesson outcomes* must be set by the teacher.
  - Teachers must ensure they have mastered the content and skills to be taught.
  - Strategies for achieving the outcomes must be planned.
  - Appropriate resources for the lesson must be planned for and collected.
  - A suitable learning environment must be provided (e.g. a display board devoted to a specific section of work), and the classroom physically prepared to accommodate the groupwork.

- ***Design meaningful groupwork tasks:*** Make sure that each task you set to be done as groupwork has a meaningful purpose - i.e. that it will serve to meet one or more of the outcomes for the lesson.

- ***Introduce the tasks in a way that promotes positive interdependence:*** If the class is to be working in groups, make that clear. Remind the groups of their group identities, or plan some other strategy to promote group interdependence.

- ***Use the opportunity*** of the groupwork (which frees the teacher up) to keep an eye on what is happening in groups.
  - Make sure the discussion in the group is to do with the work, and not just idle social chat.
  - Check that social dynamics are functioning positively. All learners should be making a contribution to the task. No individuals should be dominating the activities (either the ideas or the physical labour). No-one should be shirking.
  - Try to keep track of time, so that the work gets done in the time allocated. Learners may need to be "speeded up".
  - Check whether the task is going according to plan. If you see problems, intervene with appropriate input and feedback on how the group is doing. Praise where the learners are doing well, and get them back on track if they seem to be lost. Sometimes you will see a problem in one or two groups which make you realise you need to make an announcement to the whole class, about something that may not be clear.

- ***Provide closure:*** Make sure that at the end of group activities there is some review of the work done, to ensure that science concepts built by the learners are scientifically correct, and that all members of the class have covered all the concepts they need to know about, so no-one misses out. This is particularly important if groups have each worked on a DIFFERENT task.

Information sheet

The following information sheet for learners simply points out some important guidelines for working effectively in groups. If you are teaching the skill of *effective groupwork* you will need to design a lesson using the advice given earlier on how best to effectively teach a skill. Remember, simply handing out a set of guidelines (like the following sheet) is not an effective way to TEACH a skill. It could, however, be used to remind learners about a skill they have already been taught.

Copyright permission has been obtained from the publishers of the book, to reproduce the guidelines in our teaching package. This extract comes from the book :

Bulman, L. (1985). *Teaching language and study skills in secondary science*. London: Heinemann Educational Books.

Discussion Techniques

When you are taking part in a discussion remember the following points. They are *very* important.

1 Remember you are taking part in a discussion
(a) to learn
(b) to help other people to learn.





2 Always have a paper and pencil handy during discussions.

3 Ask for anything you do not understand to be explained.





4 If two people have misunderstood each other, help them out.

5 If someone has said something which you think is important, remind the group about it.





6 Always let other people 'have their say', even if you are bursting to say something.

7 Be prepared to change your mind if you have been proved wrong.





8 Do not shout people down just because you don't agree with them.

9 Do not show off in a discussion.





10 You must take part in a discussion even if you feel shy.

11 Listen carefully to what everyone else in the group says.





12 Always have one member of the group writing down the most important points discussed and any decisions that the group has made.

From Bulman, L. (1985) Teaching language and study skills in secondary science: Heinemann Educational London Reprinted by kind permission of the publishers



Add your own additional notes here

Making a presentation

Curriculum 2005 promotes presentations by the learners, either as individuals, but often in the form of feedback from groups on activities they have done.

Benefits of presentations

- ***Promoting knowledge construction:*** Because preparing a presentation involves planning and thinking, it provides the opportunity for learners to be mentally engaged with the work. This helps them to build an understanding of the work they are dealing with.

- ***Allowing for the sharing of knowledge:*** It seems that the new curriculum often expects different groups of learners to be engaged in different tasks. There is a risk that not all learners will cover all aspects of the science that they need to understand. Presentations can be used to allow groups to share with others the knowledge they have gained during the task done by THEIR group.

- ***Promoting communication skills:*** In real life people often have to put across their ideas, and learning to be a good presenter at school will benefit learners for the demands of life.

- ***Alleviating the boredom of traditional teaching:*** Because the learners are actively engaged, they are less likely to get bored than if they are just sitting listening to the teacher.

- ***Peer-teaching promotes learning:*** Research has shown that when students prepare work to present to others it often helps them (the presenters) understand the work better. Furthermore, being on the same level as their peers often means they understand the typical problems of the learner, and can present the work in a way other learners will understand more easily.

Possible problems with presentations

- ***Poor presentations mean outcomes are not met:*** If learners are weak presenters, or if they have not prepared well, it can be a painful waste of time listening to their talks. Furthermore, the benefits the teacher has planned to achieve will not happen.

- ***Shirkers may not benefit:*** Remember that if group members have not done their bit, they will not benefit from the exercise.

- ***Content errors may creep in:*** Because learners are not content experts, and may lack suitable resources to prepare the work they will be presenting, errors may creep in to the information they present. Teachers need to be well-prepared, and need to keep an eye

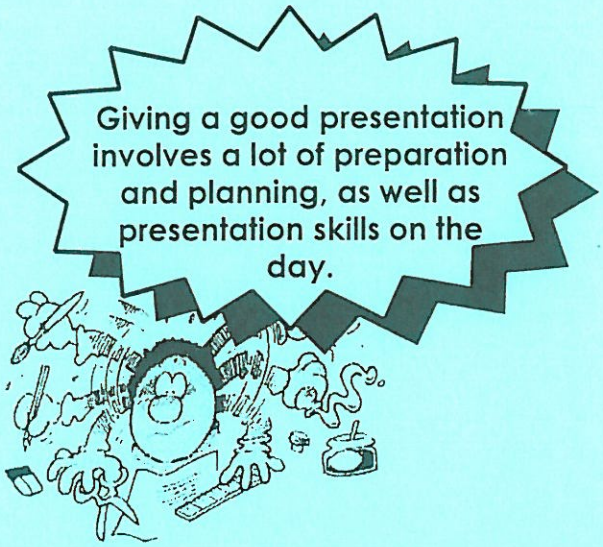
on what is being said by the learners doing the presentations. If necessary, they may have to intervene in a appropriate way which does not embarrass the presenter, but which will address any problems that may emerge. Note, the teacher should try to avoid interrupting presenters in the middle of a talk. Make notes about problems during the talk, and address them afterwards.

Information sheet

The following four-page information sheet for learners is just that - some hints on making better presentations. If teachers are TEACHING the skill of *presenting,* they will need to develop a lesson which follows the guidelines given earlier for teaching a skill, and not just hand out a set of instructions.



Making a presentation is a skill that needs to be learned and practised. Here are some hints about preparing and presenting your work which will make you a more impressive presenter.

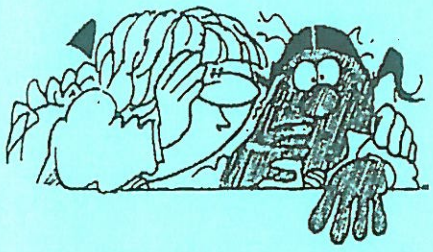


Preparing your presentation



Know what you have to do: Go over the instructions that you have been given. Make absolutely sure you know:

- the aim of the talk (so you don't wander off track),
- what you have been told to include (so you don't leave anything out, and don't include unnecessary information),
- the time allocation (it is extremely bad manners to go over your time allocation).



Know your audience: You need to think about ways of presenting which will get them interested in your talk and keep their attention.

- Think about questions that other learners might want answers to (and make sure you address these matters in your talk).
- Consider the level and language ability of the audience (and adjust the level of your presentation accordingly).

Know your content:

- Make sure that WHAT you are going to talk about is scientifically correct (does not contain errors).
- Ensure that all the points you need to cover are included, in sufficient detail.
- However, make sure that you do not have too much content to present in the time available.



Preparing your presentation (cont.)

What to include in your talk

It is important that you structure your presentation in an orderly way so that it follows a logical sequence which makes sense. If the information is jumbled the listeners may find your presentation very confusing and may not benefit anything from it. Tell it like a story, and do not miss out important bits. Have an introduction at the start, a logically sequenced middle section, and a conclusion to round off.

The start

The introduction is important because it is your first contact with the audience, and you need to make a good impression. An introduction has two important functions

- It should tell the audience what your talk is about.
- It can be used to grab the audience's attention, and to interest them in what is to come. If the introduction is boring, you will have lost the attention of the listeners.

You can introduce your presentation in many different ways, for example,

- *You may want to say why your topic is important or relevant.*
- *You could use the introduction to outline the overall structure of your presentation (i.e. to give an overview of what will be included).*
- *You could use some novel and attention-grabbing gimic to gain the audience's attention.*
- *If you have time, you could grab the attention of the audience by getting them involved in a short RELEVANT task (e.g. ask them to write down the answer to a question, or to think about something and discuss it with a partner)*

The middle

The body of the presentation consists of the main points that you want the listeners to know. It is crucial that your points are arranged in an orderly way, which makes sense to the audience.

② → ③ → ① → ④ ✗

① → ② → ③ → ④ ✓

Some of the ways you could sequence the talk are, for example

- *chronologically (i.e. in the sequence of events, as they happened in time)*
- *in order of importance;*
- *starting with the cause followed by the effect,*
- *stating the problem first, followed by a solution.*

The end

The conclusion is the grand finale to your talk. It should leave the audience with a clear message to remember, as well as a good impression of your presentation. You can do this in one of several different ways:

- *remind them of the purpose of the presentation,*
- *supply the final answer,*
- *give the punch-line,*
- *give your final thoughts,*
- *give a summary of the main points, to give the listeners a chance to review what you have said.*

Tips on how to give a good presentation (cont.)

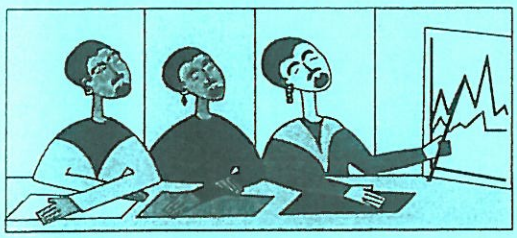


Prepare some suitable visual aids: They say that "a picture paints a thousand words". This means that it is often easier to understand something if you SEE it, rather than just hearing about it. Some of the visual aids you could use are:

- *overhead transparencies*
- *chalkboard*
- *demonstration of a process*
- *models*
- *actual objects*
- *computer slide shows*
- *posters*

Team presentations: If you are part of a team, you need to decide how to divide the work (who will do what).

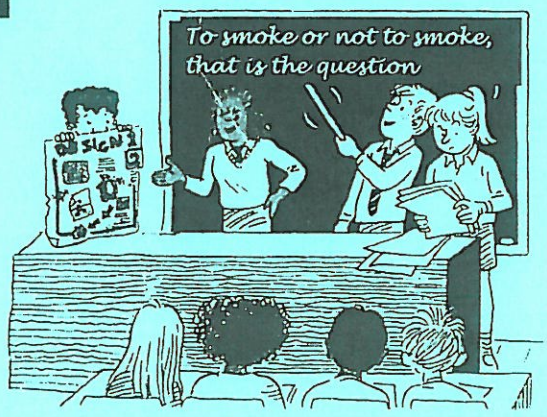
- It is best to make sure that everybody is involved, and plays some important role.
- When dividing up the tasks try to consider what each team member is really good at, and ensure they have an appropriate task so the team benefits from their skills. However, remember that each team member also needs to practice and develop skills they are not so good at.
- If there is a limited amount of time for the talk you may decide that only one member of the team will do the talking, so no time is wasted in change-overs.



Rehearsing the presentation: It is wise to rehearse your presentation in front of some friends. This will help you get over or reduce anxiety of the class presentation to come. Your friends can also give you feedback on how to improve your presentation.

Tips on how to give a good presentation

You need to concentrate on your appearance and manner, as well as on how you present the message. Here are some ideas to help you give a more impressive presentation.



***What you look like and how you act*:**

- ***Your dress:*** Make sure you are neat and professional in your dress. For certain presentations you may want to dress in a way suited to the topic of your talk (play a role).
- ***Your manner:*** You need to appear confident and in control. This will make your audience feel more relaxed. It is much easier to appear confident if you are well prepared for the talk, know what you want to say, have practised so you are fluent, and have good quality visual aids to help you during the talk.

Tips on how to give a good presentation (cont.)

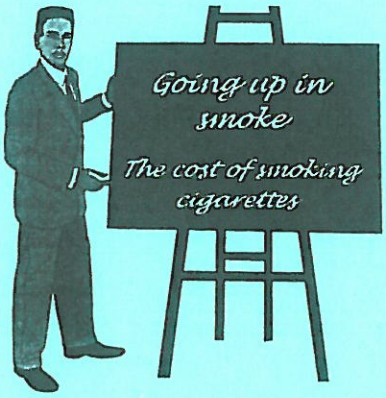
How you present:

You need to help your audience feel relaxed. If they see you are nervous and tense, they will feel uncomfortable. Here are some hints to help you.

- ***Eye contact:*** It is important to try to make eye contact with as many listeners as possible as you present because it helps create a relationship with them. Don't just look at, and speak to, people in the front row, on one side of the classroom.
- ***Audibility:*** Make sure you speak in such a way that everybody is able to hear what you are saying. It is pointless to be heard only by people who are close to where you are.
- ***Speaking naturally:*** Never try to rote-learn the whole speech, because that makes you sound artificial and stiff, and makes the audience feel really uncomfortable.
  - Use note-cards to write the main points of the presentation, to help you keep to the correct sequence.
  - If possible, use note-cards made of cardboard, and which fit easily into the palm of your hand.
  - Use large, clear, legible writing (or print) to enable you to read easily.
  - Number your cards to keep the correct order (in case you drop them!).
  - Include only the main points and supporting sub-points, written as key phrases NOT full sentences. Use these to remind you what it was you wanted to say next, and then talk about each point from memory (rather than rote-learning what you wanted to say).
- ***Use of visual aids:*** The use of appropriate visual aids makes the presentation *more interesting* as well as making the explanations *easier to understand*. It is very important to note that visual aids should be used to support your presentation not to dominate it - i.e. do not have too many visual aids.

  Here are some hints for DISPLAYING your visual aids, for example, flip-charts, over-head transparencies etc.

  - Place the visual aid so that everyone can see it (NB: make sure it is LARGE enough to be seen and that the writing, if there is any, is big enough for the audience to read comfortably)
  - Stand to one side of the visual aid, rather than in front of it. Try to ensure you do not block the view of anyone in the audience.
  - If there is a lot of writing on the visual aid, e.g. an overhead transparency, try to reveal one point at a time. This will prevent people from reading ahead and not listening to you.



Add notes on other presentation hints you may have heard about

Recording data in the form of graphs

What are "graphs"?

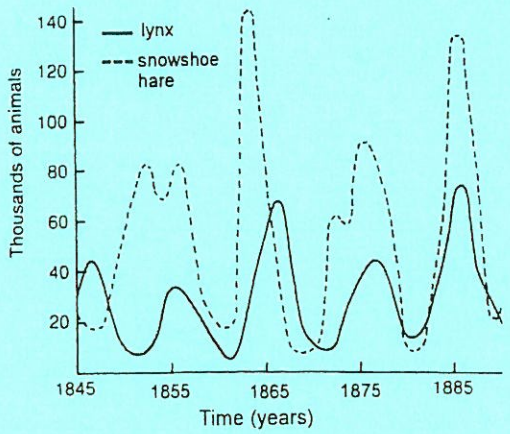
A graph is essentially a picture showing the relationship between (usually) two factors (called variables) using a series of points, plotted with reference to a set of intersecting axes.

Why use graphs?

Graphs communicate information in a way that is easy to interpret. They can often be read and understood more quickly and easily than the same data presented as text. Furthermore, graphs show trends and relationships much more clearly than do data presented in the form of text or tables, providing information in a way that can be comprehended at a glance. It is easier to pick up information from a graph, and also easier to remember things depicted visually.

This is clearly shown in the following comparison of data about the lynx and snowshoe hare populations in Northern Canada in the 1800s. While the graph shows data up until 1890, the text only gets as far as describing what happened until about 1860 before running out of space. The population changes are much more easily understood from the graph, and the relationship between the lynx and hare populations are easily seen.

In 1845 the population of snowshoe hares in Northern Canada was about 20,000, and that of their predators, the lynx, about 30,000. As the number of lynxes increased over the next 2 to 3 years, the numbers of hares declined, as they were eaten by the lynxes. From 1847 to 1851 the numbers of lynxes dropped dramatically, as a result of disease. As there were fewer predators the hare population flourished, reaching a peak of 80,000 in 1851. Although the numbers dropped to just below 70,000 in 1853, they rose to reach their former levels in 1856. However, by 1851 the population of lynxes was recovering, growing to 35,000 by 1856. Increased predation on the hare population caused ..... etc.



Variations in the snowshoe hare and lynx populations in Northern Canada in the second half of the 1800s

Who uses graphs?

Graphing is a skill needed by those wishing to communicate information as well as those wishing to receive the communication. They are used by anyone wanting to communicate or receive quantitative information visually, in order to reveal trends and relationships in the data.

- ***The "man" in the street:*** Graphs are a part of our daily lives because they are commonly used in the media, such as in television, newspapers, and magazines. For example, newspapers may present information about HIV/AIDS infection rates or death rates in the form of a graph, as it is easy to see the extent of the problem, and whether the situation is worsening or improving. Thus any citizen who is to be a thinking participant in society needs to be able to interpret information presented in the form of a graph.
- ***Professionals:*** People in business and industry often use graphs to plot information about sales or the production of goods, as it allows them to detect changing patterns and trends in the sale of goods or in production rates. For example, changes in stocks and shares over time are easier to see if presented in a graph rather than a table.
- ***Scientists:*** Graphing is a basic skill of scientists, who often use graphs to present the results of their investigations. They can present vast amounts of data in a visual and easy-to-understand format, which shows trends and relationships. Graphs allow them to communicate their findings, and to understand the work of others communicated in this way.

Because citizens require graphing skills it is crucially important to teach these to learners at school.

Graphing as a process skill

Modern science curricula are using the term "*process skills*", which need to be taught to learners. Process skills in science are usually *transferable intellectual abilities used to process information*. They are appropriate to many science disciplines and reflective of the behaviour of scientists. Science process skills can be grouped into two types, i.e. ***basic skills*** (simple, isolated, individual skills) and ***integrated skills*** (more difficult tasks often requiring a combination of simpler process skills). These skills are hierarchically organised, and the ability to use each upper level skill depends on the ability to use the simpler underlying skills. In other words, the basic process skills provide a foundation for learning the integrated skills.

Basic science process skills	
Observing	Using the senses to gather information about an object or event. This is probably the most basic process skill, as the development of the other skills are based on the ability to observe accurately.
Inferring	Making an "educated guess" about an object or event, based on previously gathered information (data).
Measuring	Using standard or non-standard measures to describe the dimensions of an object or event (e.g. volume, length, mass, time etc.) in a quantitative way.
Communicating	Using words, symbols, pictures or actions to describe objects, behaviours or event. Graphing is a very important skill for communicating data to others.
Classifying	Grouping or ordering objects or events into categories based on properties or criteria of the objects or events.
Predicting	Stating the outcome of a future event based on a pattern of evidence. The ability to predict enables people to interpret some questions on graphing which require them to estimate what might happen if one variable is changed.

These *basic process skills* can be considered as prerequisites for the following *integrated process skills*.

Integrated science process skills	
Controlling variables	Being able to identify variables that can affect an experimental outcome, and keeping most variables constant while manipulating only the independent variable. Identifying variables involves recognising constant characteristics of objects (the independent variables in the case of graphs), or characteristics that change under changing conditions (dependent variables in the case of graphs).
Defining operationally	Stating how to measure a variable in an experiment (e.g. units in graphs).
Formulating hypotheses	Stating the predicted outcome of an experiment.
Interpreting data	Organizing data and drawing conclusions from it. In order to interpret data students need prior experience in the basic process skills of making observations, classifying and measuring. Results of an experiment could be presented in the form of graphs, which provide data that learners have to analyse and interpret in order to answer questions posed.
Experimenting	Being able to conduct an experiment, including asking an appropriate question, stating an hypothesis, identifying and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and recording, analysing and interpreting the results of the experiment.
Formulating models	Creating a mental or physical model of a process or event.

Graphing skills are included in both categories of science process skills (e.g. in the basic process skills communicating could be by means of graphs to explain and relate ideas and information, while integrated process skills could involve interpreting data by means of graphing tabulated data as a graph and drawing conclusions from it).

Types of graphs

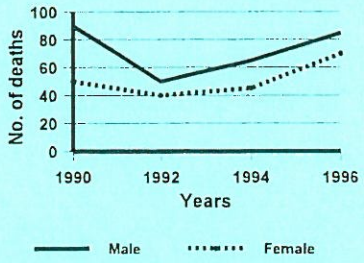
There are many different types of graphs, usually determined by the type of information which needs to be depicted. At school level, natural science learners need to know about five main types of graph - *line graphs, bar charts, histograms*, *pie charts*, and *scattergrams* (see examples and explanations on the following page).

Deciding which type of graph to use is not always straightforward, but at the General Education and Training level there are some basic guidelines the learners can follow.

1. First look to see whether one variable contains *nominal* data (i.e. the groups are named - e.g. boys and girls, days of the week, etc.). If so, use a BAR GRAPH.
2. If the data for both variables are in the form of numbers, and the data for one variable is grouped e.g. age groups in the teens, 20s, 30s etc.) use a HISTOGRAM.
3. If neither variable was controlled by the experimenter, use a SCATTERGRAM.
4. If the data needs to show relative proportions or ratios, use a PIE CHART.
5. For most other graphs a LINE GRAPH will be appropriate.

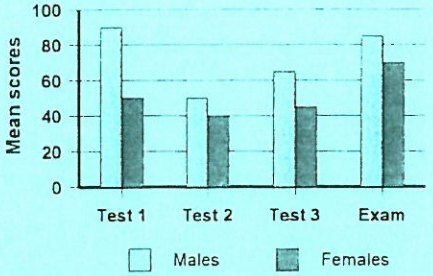
LINE GRAPHS

These best represent data that are values from continuous scales of measure. They often show a time series data set, i.e. communicate changes happening over a period of time. Both sets of data represent numbers, and one set is clearly controlled by the experimenter, and the other set varies as a result.



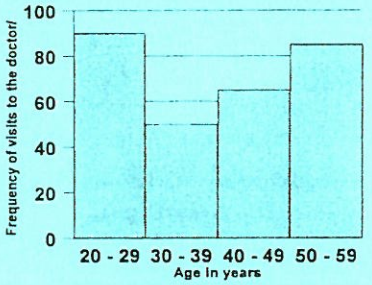
BAR GRAPHS

These show frequencies of discrete or categorical variables (ordinal or nominal data). They use bars to display the data. The height of the bar represents the value of the named variable being measured.



HISTOGRAMS

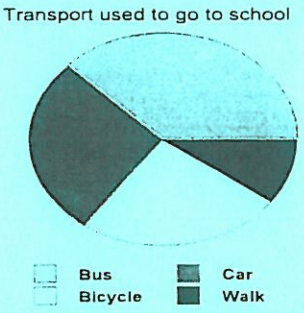
These show frequencies of continuous variables, usually in categories (classes).No value can fall between these categories. Histograms are similar to bar graphs in appearance, but the edges of each bar must be on its class boundaries, i.e. must be touching or continuous.



PIE CHARTS

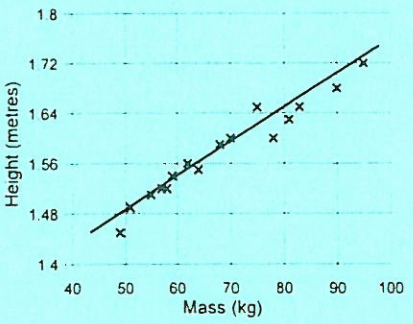
These represent data as a circular diagram that looks like a pie cut into slices. The whole circle represents the whole amount of data being dealt with. Each slice represents the value of a variable measured. They are useful for seeing the proportional relationship between components.

Graphs from Kali (2004)



SCATTERGRAMS

These represent data where neither variable has been manipulated by the experimenter, so there is no independent variable. The graph shows relationships between two variable. NB: The graph does not show that one CAUSES the other, simply that the two factors are related in some way.



Relationship between mass and height of Grade 10 learners at Kings High

Teaching graphing skills

Acquiring science skills should not be assumed to just happen. Teachers need to devote time and effort to explicitly teach these skills. Two very different skills are needed in graphing - the ability to **interpret** and the ability to **construct** graphs. Teachers also need to be aware that being able to *interpret* graphs does not necessarily mean that learners know how to *construct* graphs. These are two separate skills and each requires special attention and has to be taught in its own right. Science teachers need to provide opportunities for the development of each of these skills (Kali, 2004).

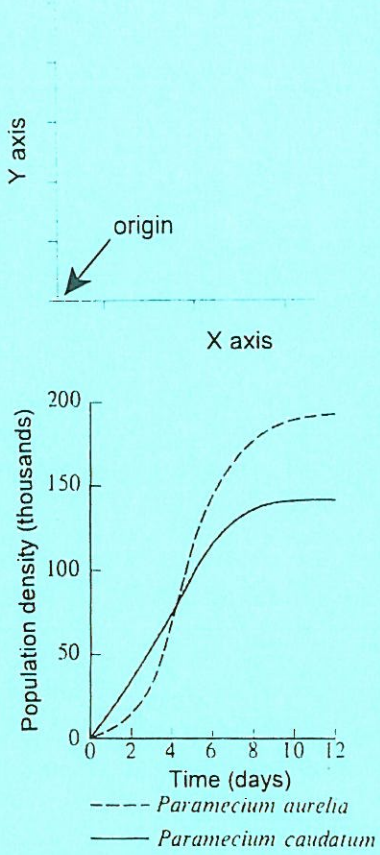
In order to understand graphs learners must

- be aware of the terms used in graphing, and what they mean.
- understand the rules of graphing, which is almost like understanding the rules of grammar.

Graphs are usually drawn on a set of two intersecting ***axes***. [NB: **axis** is singular and ***axes*** is the plural form of the word]. The vertical axis is called the ***Y axis***, and the horizontal axis is the ***X axis.*** The point at which they intersect is called the ***origin***. NB: this does not necessarily represent the zero value on each axis.

The factors which are plotted on the graph are called ***variables***, and are of two types: In the natural sciences the ***independent variable*** (the one which the experimenter changes, to see what happens) is almost always plotted on the X axis. The ***dependent variable*** (the one which will change as a result of the experimenter changing the independent variable) will be plotted on the Y axis. *For example, in an experiment to determine the effect of the amount of exercise on the pulse rate of the exerciser, the experimenter controls the amount of exercise (e.g. the number of push-ups) which will be the independent variable, and looks at what happens to the pulse rate (which is the dependent variable).*

Information needs to be clearly communicated on the graph, so each graph must have a ***title***, explaining what it is that is being shown. Furthermore, each axis must have a distinct ***axis name*** explaining what is being measured, as well as the ***units of measurement***. In some graphs a ***key*** or ***legend*** may be needed (if more than one set of variables is being depicted using different patterns or colours, *e.g. if separate information is provided for boys and girls*).



Population growth of two *Paramecium* cultures over time

Interpreting graphs

Interpreting graphs involves two processes: **visual perception** (the ability to see what is shown by the graph in terms of shape, the elements shown etc.) and **graphic cognition** (the ability to convert what is seen into meaningful information). The sorts of skills needed in order to interpret graphs include the following:

- determining what is being represented on each axis,
- looking at the units on the axes, and how they quantify the data,
- determining the values of the X and Y coordinates associated with each point on the graph
- extracting essential information from the graph, and using it to interpret the shape of the graph by describing how one variable relates to another,
- explaining trends shown in the graph in terms of content knowledge,
- interpolating and extrapolating values,
- interrelating the results of two or more graphs shown on the same set of axes,
- predicting changes in trends if one of the variables is altered.

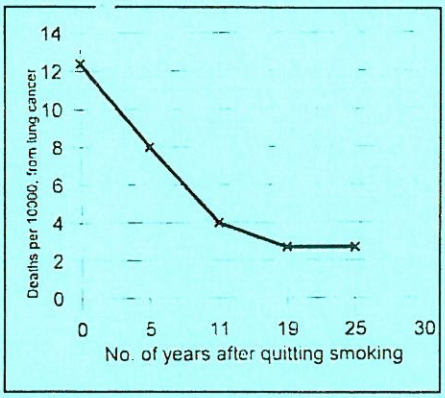
When interpreting graphs the following procedure is usually used

1. Carefully read the question you have been asked to answer. Make sure you understand what is being asked. Usually the question will give you one value (relating to either the dependent or the independent variable on the graph) and will ask you to find a corresponding value for the other variable.
2. Identify the variable you have been given, and look at the corresponding axis on the graph (either the X or the Y axis). Find the given value *on the axis*.
3. Use a ruler to link that point on the axis to the corresponding point on the graph line. If you are working from the X axis, make sure your ruler is absolutely vertical (i.e. at 90 degrees to the X axis). If you are working with the Y axis, make sure the ruler is absolutely horizontal. Mark the point on the graph.
4. To read off the correct corresponding value on the other axis, use the ruler to link the mark you have made on the graph to find the corresponding value on the OTHER axis to the one you started working with.
5. Finding values from a graph involves two processes called *interpolation* and *extrapolation*. If the point you are working with on the graph falls within values actually already plotted on the graph, you will be using *interpolation*. If the value falls outside of the values used to plot the data, then you are effectively being asked to make a prediction, as the data has not been experimentally determined. In some graphs (e.g. straight line graphs) this can easily be done by extending the line, and reading the values off the axes. However, for graphs which are not straight lines (e.g. J-curves which show changing population numbers) this can be tricky, as one is never sure what factors will affect the numbers in real life and thus change the slope of the graph). Whatever the case, when you are predicting numbers on sections of the graph for which you do not have actual data, the process is called *extrapolation*.
7. You will also often be asked to comment on the trends shown in the graph - i.e. to explain what happens to the dependent variable as the independent variable is changed. Look very carefully at what happens as the independent variable gets bigger (this is often a time change). Then see what is happening to the dependent variable (plotted on the Y axis). In your answer you need to link the one to the other using words such as "*when ...., then ...*" or "*as ... occurs, ... happens*".

   For example, "*as the number of push-ups done increases, the pulse rate rises*". However, you also need to add more detailed QUANTITATIVE information. E.g. "*as the number of push-ups done increases, the pulse rate rises steadily until it reaches a value of about 120. Then it starts to rise more slowly (relative to the additional push-ups done)until it reaches a value of about 140, where it remains more or less constant, no matter how many more push-ups are done*".

Practice exercise: Interpreting graphs

1. Using the evidence shown in the following graph, describe how quitting smoking affects the chances of dying of lung cancer.
2. How many deaths from lung cancer (out of every 10,000) would you expect to be of smokers who had quit for two years?
3. How many deaths from lung cancer (out of every 10,000) would you expect to be of smokers who had quit for thirty years?
4. How much less likely are you to die from cancer 25 years after quitting, than just 2 years after quitting?



The effect on death rates, of length of quitting smoking

Constructing graphs

Skills needed for graph **construction** include the following:

- selecting the appropriate type of graph to plot from any given data, which requires first identifying whether the data is continuous or discontinuous (discrete),
- identifying dependent and independent variables, and assigning each to the correct axes,
- drawing the axes and developing suitable scales for each,
- plotting points on the graph from data provided in tabular form,
- constructing a line of best fit,
- providing a suitable title for the graph,
- correctly annotating the graph, if required (by providing a legend / key).

When constructing line graphs a number of steps are usually followed.

Step 1: Decide on the type of graph to use

Look at the type of data and what is being shown, and decide what type of graph would be the best to use to present the data. Remember:

- If the independent variable is a named category rather than a measured value (i.e. if the data is nominal data), you need to use a **bar graph.**

- If the independent variable consists of a range of continuous values clustered into groups (called ***classes***) you should choose a **histogram**.
- If you are trying to show ratios or proportions of something, a **pie chart** is best.
- If you want to show changes in one variable as another variable changes (e.g. changes over a period of time) **line graphs** are best.
- If neither variable has been controlled (by an experimenter) use a **scattergram.**

Practice exercise: Deciding what type of graph to use

What type of graph would be best to plot the following data?

1) the effect on the pulse rate of running different distances.
2) the number of species of animals in each class of vertebrates, as a percentage of the number of species of vertebrates.
3) the marks which learners got for *physical science* and for *mathematics.*
4) the average height of learners in Grades 8 to 12.
5) the amount of oxygen produced as a plant is exposed to different intensities of light.
6) the amount of oxygen produced when plants are exposed to red, green and blue light.
7) the number of deaths from HIV/AIDS of people in their teens, their 20s, their 30s, their 40s etc.
8) the percentage of different gases in the air we breath in.
9) the average mass of boys and girls in Grades 1 to 7.
10) the pulse rate changes over time after a person has smoked a cigarette.

Step 2: Identify the variables involved, and decide which one goes on which axis

Remember that the independent variable goes on the X axis, and the dependent variable on the Y axis. Learning to identify which variable is which may require some practice. In each of the following pairs of variables, identify which is the *independent variable* (the one being controlled by the experimenter) and which the *dependent variable* (the one which changes as a result of changes in the independent variable).

Practice exercise: Identify the dependent and independent variables

For each of the following sets of data, identify which variable is the dependent and which the independent, and state on which axis each would go (X or Y axis).

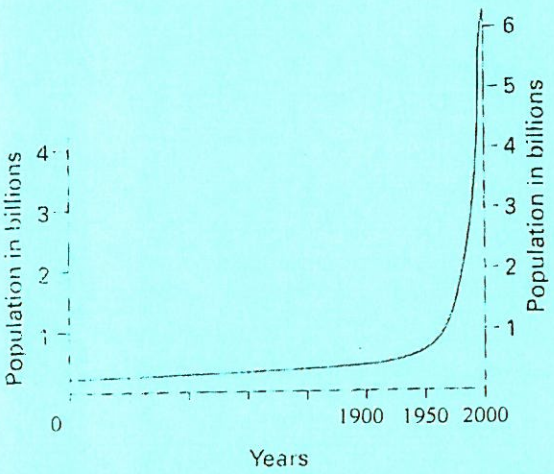
1) the number of minutes a piece of pond weed in a beaker of water is placed in the sun and the number of bubbles of oxygen released.
2) the marks you get for a test and the number of hours you studied for the test
3) the number of cigarettes of a particular brand sold and the amount of advertising done by the cigarette company.
4) the average height of the girls and the boys in Grades 8 to 12.
5) the time taken to swim an increasing number of laps of the pool.
6) the number of deaths from HIV/AIDS in people in different age groups (e.g. their teens, their 20s, their 30s, their 40s etc.)
7) the marks which learners got for *biology*, and for *physical science*.

Step 3: Choose an appropriate scale for each axis

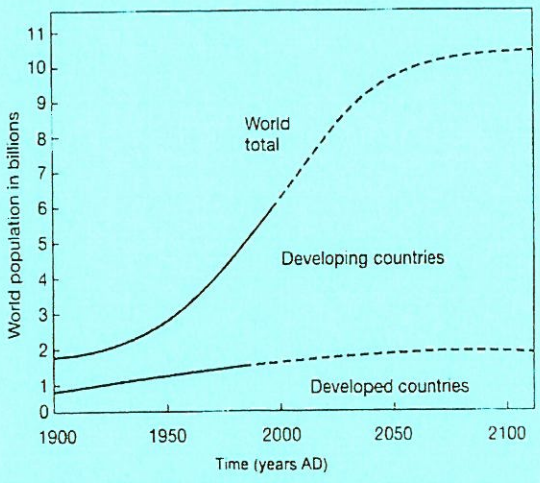
The main idea behind choosing a suitable axis is to use the graph paper effectively so the graph fits onto the paper, and covers most of the area (does not leave sections of the paper unused).

1. First examine the highest and the lowest values you need to plot for each variable. Also decide whether you need to plot the data from zero (see advice under point 5, below).
2. Then count the number of squares available for the relevant axes on the graph paper.
3. Choose an appropriate scale which will allow you to fit all the values on the axis, and which allows you to divide the spaces easily. Graph paper is usually divided into blocks of 10 squares, so it is easier to choose multiples of 5 or 10 for the scale. Try to use the whole length of the axis. You may have a few small squares left over, but you should never choose a scale which leaves you short of space (which would mean you could not fit all your data on the graph).
4. Make sure that you USE the space on the graph wisely. For example, if you are plotting test marks (in percentages) on the Y axis, it is pointless including percentages up to 100% if the highest test score is only 63%.
5. The scale should usually begin at zero (at the origin of the graph, where the X and Y axes intersect). However, sometimes this is not feasible because of the values you have to plot.

   For example, when plotting changes in population numbers since the year 1, the changes are so small for the first 1800 years that you hardly see any changes on the graph. The dramatic changes have happened in the last 200 years, and that is the data you need to highlight in the graph. If you want to show population numbers for the earlier years, but want to avoid a long straight line before any changes are seen, you could cut out the data for the middle years. You must then indicate a break in the graph, by using a small double line across the axis, and also indicate a break in the line graph (see first diagram below). Alternatively, you could just start plotting the years from a later period, as show in the second graph below, where dates begin at 1900.

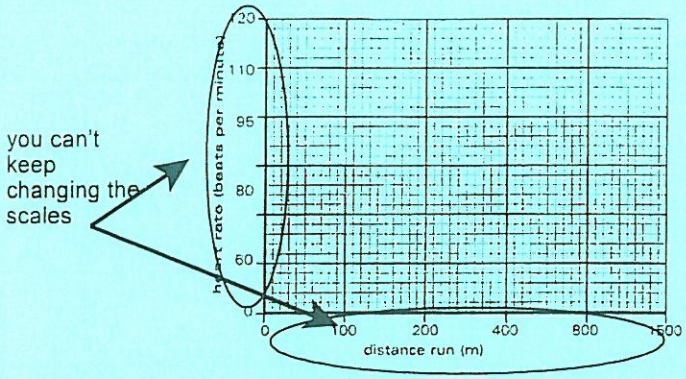


World population figures from 0 AD until 2000



World population figures from 1900AD, with predicted figures until 2110

6. You MUST keep the scale constant. You can't change the scale for different sections of the axis. The figure on the next page shows how the scales on both the X and the Y axes have been inappropriately altered

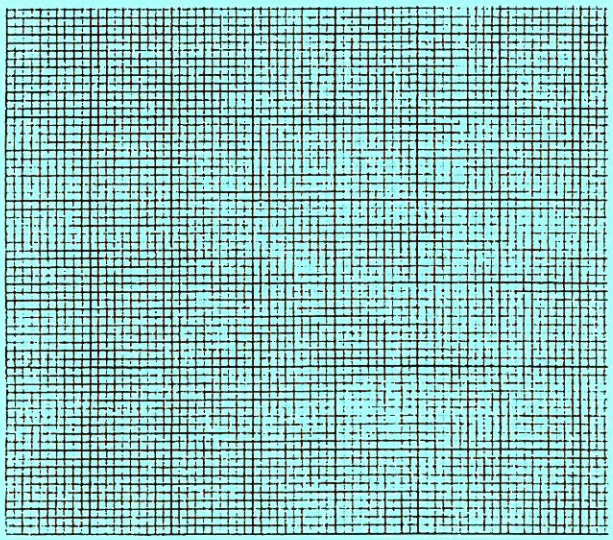


Inappropriate scaling on both of the axes.

Practice exercise: Scaling the axes appropriately

If provided with the piece of graph paper below, choose suitable scales for

1) your mass (55kg to 75kg) and the number of sweets you eat per day (from 0 to 20)
2) the number of bubbles of oxygen released (0 to 22) and the number of minutes a piece of pond weed in a beaker of water is placed in the sun (0 minutes to three hours)
3) the marks you get for a spelling test (0 to 10) and the number of hours you studied for the test (0 to 4 hours).
4) the number of boxes of cigarettes of a particular brand sold per week (1000 packets to 10,000 packets) and the amount of advertising done by the cigarette company (0 TV ads a day to 45 TV ads a day).
5) the number of hours of training you do each day (½ hour to 4 hours), and the speed with which you swim a lap of the swimming pool (39 seconds to 28 seconds).



Step 4: Plot the points on the graph

1. Using the two sets of data, plot each point on the graph. To do this
   - find the correct axis (e.g. the X axis for the independent variable), and find the correct point on the axis for the value given.

- now find the corresponding Y axis value to plot the same data point.
- move vertically up from the X axis value, and horizontally across from the Y axis value, until the two values intersect.

2. Indicate the point with a small cross rather than a dot, as a cross is more accurate and more easily visible.
3. Join the points with a smooth free-hand line smoothing out the curves. Do not join the points using a ruler.
4. Note, graphs in the natural sciences often do not go through zero. The graph can only go through zero if the value of the X axis and the value of the Y axis are actually zero for one of the points on the graph. This is often not the case (one of the values may well be zero, but not the other). Do not plot a graph through zero if the data does not support this.

Step 5: Add all appropriate information to the graph

1. Add a title to the graph which explains what the graph is showing (including both the variables involved).
2. Label each of the axes with a suitable name which describe the variable, and which includes the units of measurement.
3. Add any annotations which might be required to explain specific parts of the graph (e.g. if a particular chemical is added at some point).
4. If more than one graph is plotted on the same set of axes, add a key (legend) to explain the colour or pattern / symbol coding you have used to distinguish between the two graphs.

When constructing histograms

Remember that histograms are used when you are dealing with categories of variables which are clustered, and where you cannot have a value that occurs between the clusters.

It is easy to spot these when data is grouped (e.g. percentage marks in the 90s, 80s, 70s etc.).However, sometimes it is not so obvious. *For example, if you are watching the number of times a swallow enters its nest during a 24-hour period on Monday, Tuesday, Wednesday etc. it is not so clear. Clearly data can never fall outside these times, so this should be plotted as periods labelled as days of the week. Similarly, rainfall for the month should be plotted as a histogram, but the "classes" on the X axis can just be labelled with the names of the months (they do not have to show the number of days, although that is really what is clustered in each named month). The bars on the histogram should touch each other.*

When plotting pie charts

Pie charts are usually shown as circles which have the data in segments which look like slices of a pie. It is crucial that you remember that a circle is made up of 360 degrees. This is the basis of the logic of constructing pie charts.

Example 1

Animals found in a trap	Number caught
Earwigs	2
Ants	10
Spiders	3
Springtails	4
Centipedes	1
	20

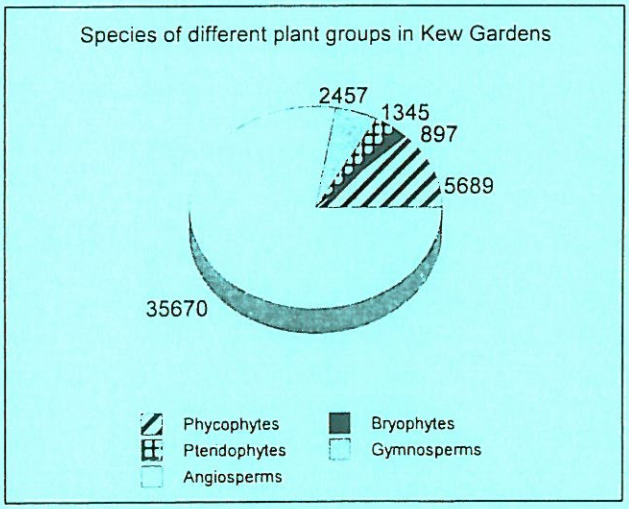
Example 2

Plants in Kew Gardens	No. of species
Phycophytes	5,689
Bryophytes	897
Pteridophytes	1,345
Gymnosperms	2,457
Angiosperms	35,670
	46,058

1. Identify the named categories of information, each of which will form one "slice" of the "pie" (*the types of animals trapped, in example 1, and the plant groups, in example 2*)..
2. Find the frequencies you have been given for each category, and add them up to find the total value for the pie (*e.g. 20 in the case of the trapped small animals in the first example above, and 46,058 in the case of the number of species of plants in the second example above*).
3. Calculate how many degrees of the circle will represent each category, based on the frequencies. *In the first example 20 animals were trapped, which must be divided amongst the 360degrees of the circle. i.e. each animal will take up 360/20 = 18 degrees of the circle.* If the total number is small you can simply divide the circle into the appropriate number of segments.

   If the numbers are difficult to picture mentally, you will need to work with a protractor and measure the segments. In the second example above, 46,058 species must be divided among the 360 degrees of the circle, so each degree must equate to 128 species. Calculate the number of degrees for each plant type by dividing the toal number of species for each plant by 128, to see how many degrees you must use for the "slice" representing that plant.
4. Starting at the top of the circle (the 12 o'clock position, colour in the appropriate number of slices to represent your first category (i.e. *colour 2 of the 20 segments to represent the earwigs caught*), then the next 20 segments to show the ants, etc.

   NB. When the pie chart is finished you should not be able to see the individual numbers, only the main categories. Make sure that when you have coloured in all the slices you are back at the 12 o'clock position.



An alternative method for calculating the size of the slices it to work out each slice as a fraction of the circle (e.g. 2457 gymnosperms divided by 46058 total plant species) and multiply this by 360 degrees. This tells you the gymnosperms will take up 2457 ÷ 46058 x 360 = 19° of the 360° circle.

Useful references

Ayerst, P., van der Schijff, H., van Rensburg, N. and Roux, J. (1989). *Data response exercises in biology.* Pietermaritzburg: Shuter and Shooter.

Learning Channel. (2001). *Natural Sciences Grade 8 outcomes based supplementary learning material.* Learning Channel Campus.

Kali, D. (2004). First-year university biology students' difficulties with graphing skills. Unpublished MSc research report. University of the Witwatersrand, Johannesburg.

Conducting surveys

One of the requirements of *Curriculum 2005* is that the learners become more independent in finding out information. This does NOT mean they have to find out for themselves everything they need to know . This is certainly not what a survey is all about. Surveys are usually used as part of a project or assignment in which the learners need to investigate a situation (to discover facts and opinions). *For example, learners could do a survey on dietry habits of learners in their school. This might involve finding out what foods are served at the tuckshop (fact), what foods learners tend to bring in their lunches from home (fact), what learners know about nutritional values and balanced diets (fact), what foods they prefer to eat (opinion), what food they think should be served at the tuckshop, and why (opinion).* Surveys are not about going and reading up on something to find answers.

Because the *Science-Society-Technology* approach is often about problems and issues in the community, an important step in the STS approach is for the learners to find out more about the problem or issue they are working with. This often involves conducting a survey to gather information about FACTS or people's OPINIONS. There are three main ways to gather information: questionnaires, interviews, and observations. The two methods learners are most likely to use are questionnaires and interviews.

Questionnaires

These are written questions, to which respondents provide written answers.

Benefits: These can be a useful way of gathering information from large samples. They can be quickly administered and, if well designed, can be quick to analyse.

Potential drawbacks: It is not easy to design a good questionnaire. The instructions and wording need to be very carefully done (and probably checked by the teacher). If they are completed when the "researcher" is not there, you cannot be sure that they were filled in by the target person. Also, you can never be sure that people are answering honestly.

Questionnaires therefore need to be carefully designed. Never make them too long. Word the instructions about how to answer, as well as the questions, very carefully.

Interviews

In interviews both questions and answers are provided verbally, and the interviewer and interviewee meet face-to-face.

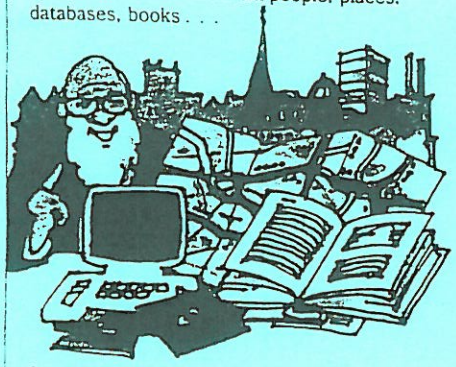
Benefits: In an interview, it is easier to explain if the person does not understand the instructions of questions, and it is easy to probe further if the interviewer does not understand the answers given (or if they are incomplete). You can also be sure the respondent IS the target person.

Potential drawbacks: Respondents may feel threatened by face-to-face encounters, and may also tell you what they think you want to hear, rather than the truth. Interviews also take much longer to conduct (than administering questionnaires), so fewer people can be sampled in a particular available amount of time. They require great skill to conduct, and can be time-consuming to analyse.

Some useful hints are given in the following three sets of guidelines, which have been reproduced with permission of the publishers, from Ridgewell, J and Davies, L. (1990) *Skills in design and technology*. USA: Heinemann Educational.

Gathering information

In order to develop a **design proposal** you need to gather information to help you make choices. Information can come from people, places, databases, books . . .



Sources of information

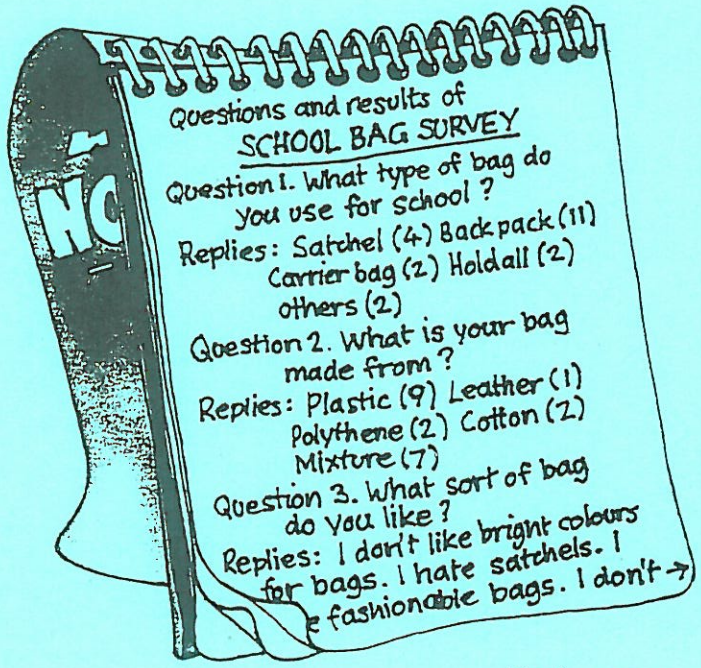
But you need to *sort* the information into *facts* and *opinions*.

Fact or opinion?

Facts are things you can see, measure and check for yourself.
Opinions are people's views . . . what they like, dislike or think about things.

Discuss

A group of pupils wanted to design a new school bag, so they asked other pupils for information.
Look at the answers to their **questionnaires**.
Which replies are *facts* and which are *opinions*?
How could they present their results?



School bag survey

Recording facts

If you are collecting *facts*, such as the number of different types of school bag, you can *count* the results.
One quick way to count is called tallying.
Instead of using numbers 1, 2, . . . you can make a mark (|) called a **tally**.
The fifth mark goes across the other four.

Results of bag survey

Types of bag	*Tally*	*Total in numbers*
satchel	1111	4
back pack	𝍸 𝍸 1	11
holdall	11	2
carrier bag	11	2
others	11	2
Total number of bags		21

Discuss

For practice, conduct your own survey on school bags. You can use the questions above or invent your own. Find out *facts* and *opinions*.
Complete a *tally chart* of results which show the facts.
How could you record or present opinions?

Opinions

Opinions are important because they consider other people's needs and views. You may find that other people's opinions give you ideas for further investigation.



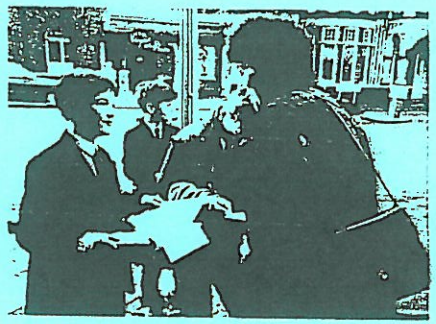
Some people have unusual opinions

To research designs for a school bag which could meet the needs of most pupils, you could ask for their *opinions* – an *opinion poll*!



Discuss

In a group, imagine that you had collected the opinions about school bags above from other pupils.
You would need to gather more facts to support your design proposal.
What ideas can you develop from these opinions?
Test out your ideas in the form of a questionnaire (see page 16).



Asking questions to collect information

Ridgewell, J. And Davies, L. (1990). *Skills in design and technology*. USA: Heinemann Educational.
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Questionnaires

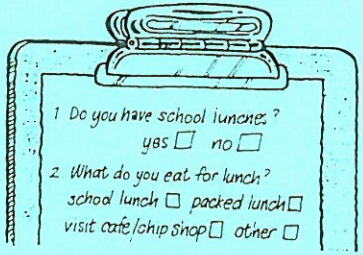
When you want to find out what people think, you ask them questions. A **questionnaire** is just one way of organizing this information by using a list of questions.

Designing a questionnaire.

- What is your *aim*? What do you need to find out about? Write a *title* for your questionnaire to remind yourself.
- Write out the questions in rough first, then test them out on others. You may need to make changes if they don't make sense.

Writing questions.

- Ask easy questions first, otherwise you put people off!
- Try asking questions with a 'yes' or 'no' answer or with just two answer choices.
- Try multiple choice questions where there are several answers to choose from.



These are *closed* questions – questions with straightforward answers. The answers are **facts**.

- Include a question to find out **opinions** – what people think. These are called *open-ended* questions.
- *Check* that your questionnaire meets your *aim* – what you need to find out.
- Plan it out.
- Leave spaces for the answers.
- Use boxes to tick off replies.

You can write out the questionnaire by hand, type it or use a word-processing program on a computer.

Here are some hints for organizing and filling in questionnaires.

- Get organized before you start. You may need several copies of your questionnaire, a clipboard or folder, pen or pencil.
- Get permission to leave lessons for out-of-school visits.
- If people are busy, leave them the questionnaire and arrange to collect it later.
- Be polite when you ask people questions.
- As soon as you have finished, sort out your results.

Getting results

Think about who will fill in the answers to your questionnaire – you or the people themselves. How will you keep a record of the replies – by writing or recording what they say?

Discuss

Look at the *carrier bag survey* opposite.
What do you think is the *aim* of the questionnaire – what information are they seeking?
Decide which of the questions are finding out

- facts – closed questions
- opinions – open questions.

How do you think the results of this survey could be used?

Design and make

Questionnaires are not easy to design.
Plan and test out a short questionnaire. Work on your own, in pairs or in a group. Use the ideas from these pages to help.
Test out your questionnaire on a friend.
Ask for their comments on how you could improve your questionnaire.
Rewrite your questions if necessary.

CARRIER BAG SURVEY

Name of Respondent _____ Date _____

Sex: Male ☐ Female ☐

Age: Under 16 ☐ 16–34 ☐
35–64 ☐ 65+ ☐

(Please tick appropriate boxes)

This is your first/second re-usable carrier bag (code ___)

Please use the carrier bag at least once with a full load of shopping etc. before answering the following questions.

Thinking only about the HANDLE of the carrier bag, how does it feel in your hand when the bag is fully loaded? Does the HANDLE FEEL:

Very comfortable	☐	(Tick appropriate box)
Fairly comfortable	☐	
Neither comfortable nor uncomfortable	☐	
Fairly uncomfortable	☐	
Very uncomfortable	☐	

And now thinking about the OVERALL STRENGTH of the carrier bag, would you say the bag is:

Very strong	☐	(Tick appropriate box)
Fairly strong	☐	
Neither strong nor weak	☐	
Fairly weak	☐	
Very weak	☐	

Taking everything into consideration, how SATISFACTORY did you find this re-usable carrier bag which you might have purchased in the normal way. Was the bag:

Very satisfactory	☐	(Tick appropriate box)
Fairly satisfactory	☐	
Neither satisfactory nor unsatisfactory	☐	
Fairly unsatisfactory	☐	(please answer below)
Very unsatisfactory	☐	

If you found the carrier bag unsatisfactory in any way, please give your reasons below:

_____

_____

_____

_____

Thank you for your help.

Ridgwell J. and Davies L. (1990) Skills in Design and Technology: Heinemann Educational USA

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Using a tape recorder for interviews

A tape recorder can be a great help in your design and technology work. It can help you with your research, collecting information and presenting your results.



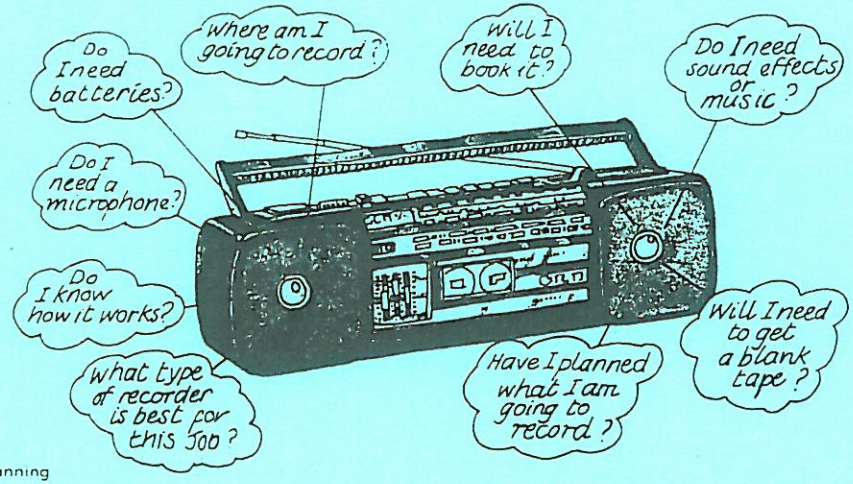
Discuss

Discuss in your group what a tape recorder would be useful for.



What to use a tape recorder for

Planning to use a tape recorder



Planning

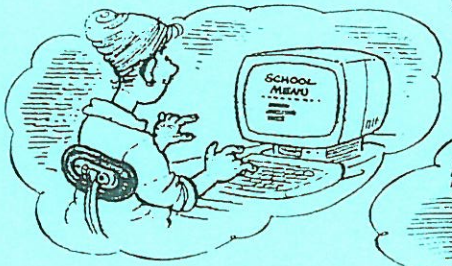
School lunches

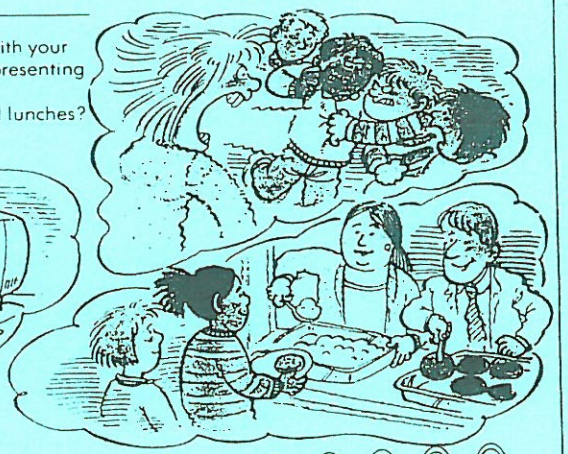


The lunch queue

Discuss

How could a tape recorder help you with your research, collecting information and presenting your results?
Who could you interview about school lunches?





School lunches: what do people think?

Plan

How would you record people's answers to your questions?
What things will you have to think about if you use a tape recorder?

Discuss

Discuss in your group the things you would have to remember if you were recording an interview with someone about the school lunch queue.

Here are some tips for interviewing

- decide who would be able to answer your question and give you the information you need. You may need to get permission from your headteacher. You may also have to make an appointment.
- make a list of the questions you want to ask and use a clipboard.
- approach the person very politely and thank them at the end.
- practise using the tape recorder first.
- if you are working as a group divide up the tasks so that one person is reading the questions whilst the other is recording the information.

Tips for interviewing

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Designing fair experiments

There is a heavy emphasis in the new curriculum on getting learners to design their own experiments. This involves many sub-skills.

1. Identifying problems
2. Thinking of possible explanations (hypotheses)
3. Designing a fair way of testing if these explanations could be correct or not.
4. Planning suitable ways of recording and analysing data.
5. Interpreting the data and then evaluating their data and solutions.

One of the best ways to get learners to understand when a test is fair, is to set up a situation where the test is obviously NOT fair. They soon get the idea. Here is a suggestion for teaching this skill.

Suggestions for teaching the skill of *designing fair experiments*

One of the best ways to get learners to understand what a fair experiment is is to get them involved in an experiment that is clearly UNFAIR, and then get them to critique it.

Here are some ways in which you could do this.



Suggestion 1: An experiment to test the softness of wood

What you will need

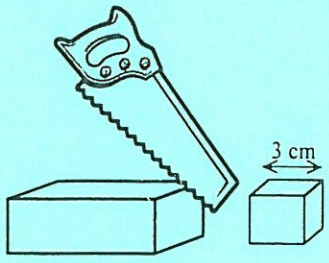
- one ***hammer*** per group (select different types of hammers)
- four ***blocks of different types of wood*** per group, labelled A, B, C, and D (± 3cm cubes)
- six ***nails*** per group (they need four, but have two spares)
- one ***telephone directory or a pile of newspapers*** per group (to protect desk or floor as they do the nailing).
- two ***plastic or paper bags*** per group (to make handing out equipment easier).

PREPARATION

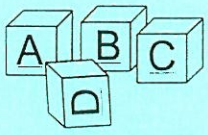
This lesson requires some careful preparation so everything is set up ready for the lesson.

1. ***You will need to have some small blocks of wood of four different types*** (every type of wood has a different hardness or softness). The easiest way to get these blocks (if your family has no garage with bits of wood lying around, and if the school does not have a woodwork centre) is to go to the local timber shop where they sell and cut wood - for example *Timber City*. Explain to the people what you are doing, and ask if they have small off-cuts of wood you could have. Try to get long narrow planks you can cut. They are usually very accommodating.

   The blocks need to be about 2.5 to 3cm cubed, so look at the off-cuts and choose planks roughly the right size, so you will have a minimal amount of cutting to do. Select woods which seem to be of different hardness. I usually take *pine* (the easiest to get), *chipboard* (which is made of packed wood-fibres glued together, and which looks deceptively soft but is really hard as rock because of the glue), *meranti* (fairly common) and then any other type they have which is visibly different.



Cut the off-cuts into cubes, and use a thick koki pen to label each type conspicuously with a capital letter (e.g the pine blocks could be **A**, the chipboard **B**, the meranti **C** etc. Because the letters A and D are easily confused if not carefully written (remember the learners will not know which way up the blocks go, when you hand them out) underline the **A** and the **D**.



Sort the blocks into sets (one A, B, C and D) and put each set in an old shopping bag, for easy handing out.

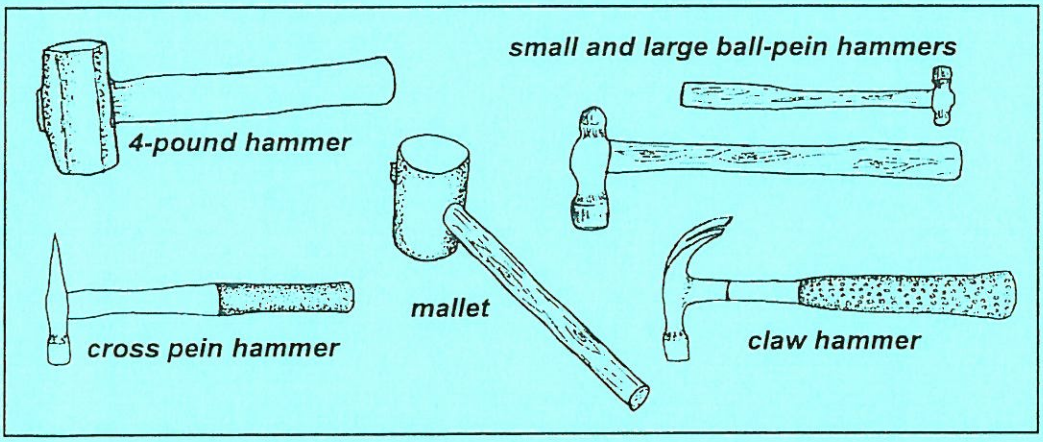
2. ***Get some nails:*** When I first did this lesson I used a variety of different nails, but it became too obvious too soon that the experiment was not fair. I did not want them to realise this until much later in the lesson, so now I give the groups six identical nails.

   The nails should not be too long (otherwise it takes forever to get them into the wood) and also not too short (as it is then difficult to hold then while you are hammering, and fingers get hurt!). Nails about 20mm are fine. Either use *panel pins* (although they have no heads and can be difficult to hit) or *clout nails* (which have a big head which is easy to hit, although the nails are rather fat).

   Although only four nails are needed per group, groups sometimes make a mess of the hammering, and cannot recover the nail to use it again. I therefore give each group six nails.

   So that the nails do not get lost I recommend you sellotape them to the head or handle of the hammer.

3. ***Collect a set of different hammers:*** In order to make the experiment unfair you need to have hammers which are very different - e.g. some *"four-pound" hammers*, some large *claw hammers,* some *small ball-pein hammers*, and any other small types. Because you need one hammer per group, you will probably need to borrow some hammers.



   If you borrow hammers from other people, use masking tape to write their names on, and tape it to the hammer so you know who to return each one to.

4. ***Telephone directories or newspaper***. Whether the learners do the hammering on the desk or on the floor, you need to protect the classroom. I use telephone directories for them to hammer on, but you could give each group a thick folded newspaper.



5. ***Make up the groups' packets:*** Now sort the equipment so each group has a hammer and nails, and the telephone directory or newspaper.

   Put the equipment for each group into a plastic shopping bag (e.g. *Pic 'n Pay* or *Shop-rite*). There are two reasons for this. Firstly, it makes it quick and easy to hand out the items, without wasting too much class time. Secondly, it is imperative that when you hand out the items the groups do not see the other groups' hammers. Hopefully they will be so engrossed in their work they are unlikely to look at what the other groups are doing.

6. ***Prepare two tables (not the furniture type) for recording the groups' predictions and their results:*** It saves a lot of time in the actual lesson if you have prepared the tables in which they will record their results for class comparisons. We have included overhead transparencies which you can use if you have an overhead projector. If not, you will need to copy the tables onto the chalkboard before the lesson, or while learners are examining their blocks of wood in class.

THE LESSON ITSELF

1. Explain to the class that they will be doing an investigation to find out which wood is the hardest. Ask each group leader to come up and fetch the packet containing four blocks of wood they must use (each group should get four different blocks - A, B, C and D).
2. Ask the groups to examine the blocks carefully and to rank them from the hardest to the softest. Encourage the groups to discuss the matter with their group members so they come to a group decision about the ranking, and why they think the way they do. NB: *Groups must stick with their predictions once they have made them, and not make changes when they see the other groups' predictions.*
3. Ask each group to give themselves a name, so their group can be identified. Encourage them to be creative in the name, and to link it to the task they are doing.
4. Once each group has decided on their ranking, call a representative from each group up to the board (or overhead projector) to record their groups' name and their prediction on the table you will have prepared. The representative must have the group's list of letters, ranked from hardest to softest, and record their predictions in the table you prepared. (Make sure groups do not change their predictions).

   Once all the groups have filled in their data, ask for some volunteers from two or three groups with very different predictions to explain how they came up with their predictions (i.e. how they decided which wood was the hardest). You will probably get a range of ideas, e.g. they looked at the grain of the wood to see which looked dense; they scratched it with their finger nail, etc.)
5. Now explain to the class that scientists would not be satisfied with just predicting - they would actually test the woods to see if their predictions (which scientists call *hypotheses*) are correct.

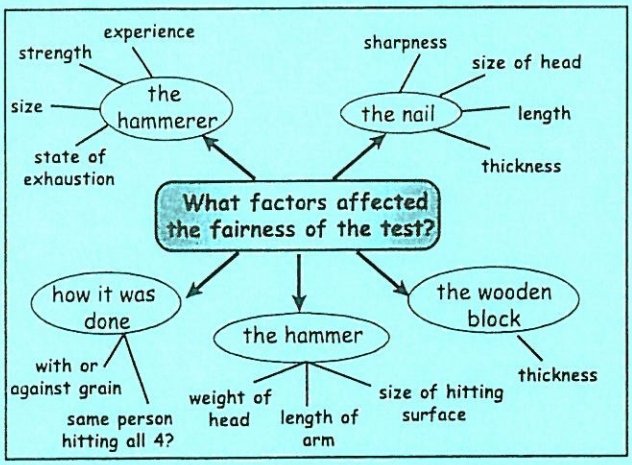
   As science students they need to design an experiment to check the hardness of the woods. ***At this stage do NOT mention the term "fair experiment".*** Ask them to discuss their ideas in their group, and to choose one person to report the groups' best idea to the class.
6. Select some groups to explain their design (for example, you could ask groups to allocate a mark out of 10 for how brilliant they think their ideas are. Ask which groups got 10/10, 9/10. 8/10 etc. to see which group reports first.) Do not allow groups to report if their idea has already been presented by another group.
7. Once all the ideas have been reported, explain that they will be using a method where they hammer a nail into each block of wood, and count the number of hammer-hits it takes to knock the nail completely into each block of wood. They must count the hammer strokes and record them for each wood. The number of hammer strokes will be used as a measure of hardness, with the smallest number of strokes being taken to indicate the softest wood, and the largest number of hits the hardest wood.
8. Ask each group to come and fetch a packet with their hammer and nails, and explain that they should work on the floor, using the newspaper or telephone directory as a "table" to prevent the floor getting damaged. NB: *Working on the floor will protect the desks, and will also hide the different hammer sizes from the different groups.*
9. When they have done the task, ask the groups to return to their group desk, with their equipment and wood.

   Ask a representative from each group to come up and record the number of hits (for each block of wood) on your second prepared *table of results* (see prepared overhead transparency for an example).

As the groups see the huge range in the number of hits for the different groups there will be much hilarity and discussion. You can contribute by making humerous comments about girls not being so good at hammering (or the other way round, if you get a girls' group with low hit numbers), or the hefty size of a member in particular groups, or their woodwork skills.

At some stage the hammer size needs to be observed. Usually someone in the class will notice the hammer of an adjacent group (the hammers and blocks of the wood should now be on the groups' desk) and they may start shouting "unfair" and draw the attention of the class to some other groups' hammer. **If they do not notice** you need to ask one of the groups which has a very large or a very small hammer if their hammer was working properly, and ask them to hold it up. Once the size discrepancy is noticed, ask each group to hold up their hammer. The cries of "unfair" will soon surface.

10. Explain to the class that in science it is very important that scientists design FAIR experiments. Ask the class to tell you what factors they think might have affected the "fairness" of the experiment they did. Record their answers in the form of a mind-map on the partially constructed overhead transparency provided. As you listen to their answers and record them, try to cluster them into "factors" so that you end up with a transparency something like this.



11. Explain that scientists call the factors which affect experiment "variables" and they try to keep all the variables constant if they design a fair experiment, except for the one they are testing (in their case the **type of wood**).

When the learners are designing experiments they should try to anticipate all the variables, and keep them constant, so that the experiment is fair.

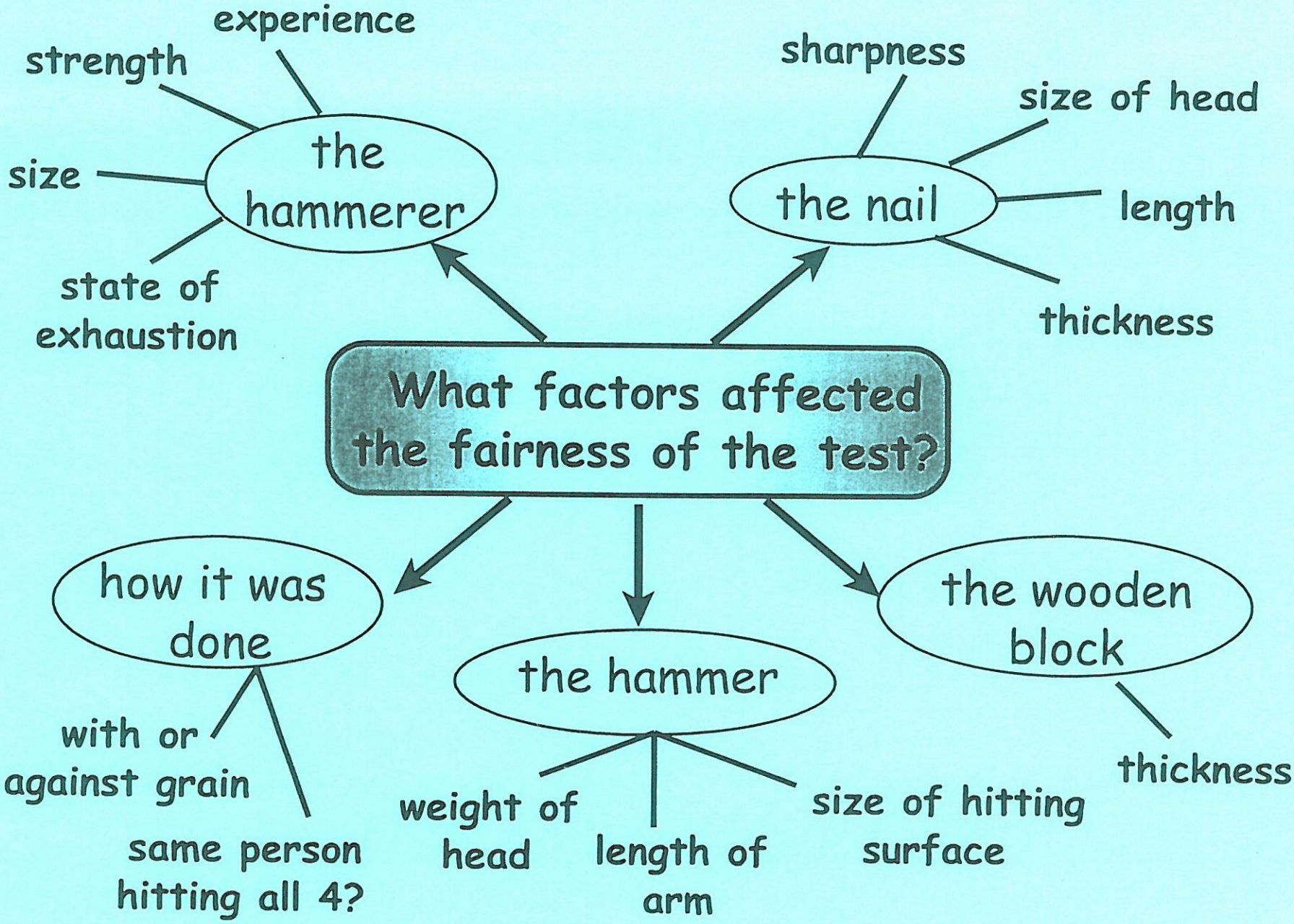
Predictions by the different groups

Group name	hardest ⟵ softest			

No. of hits needed (to drive whole nail in)

Group	A	B	C	D	Hardest to softest

What factors (variables) affected the fairness of the test?


What factors affected the fairness of the test?
the hammerer
experience
strength
size
state of exhaustion
the nail
sharpness
size of head
length
thickness
how it was done
with or against grain
same person hitting all 4?
the hammer
weight of head
length of arm
size of hitting surface
the wooden block
thickness



Brainstorming

Brainstorming is a technique used by groups to come up with a large and varied number of ideas. The DOVE rules for brainstorming emphasise the important features of this technique.

.The DOVE rules for brainstorming

Defer judgement	This means do not sit and discuss each idea which comes up. Accept them all, and write each one down.
Opt for the original and offbeat	This means you should try to think differently - and not just come up with conventional or common ideas. Think "outside the box".
Vast numbers of ideas are best	This refers to the fact that the purpose of brainstorming is to come up with as many ideas as possible. Try to break each idea up into many sub-ideas, and list each one separately.
Expand (or piggy back) off the ideas of others	This means that something someone says might trigger off a similar but new idea in your mind - use the ideas of others to think of new ones for yourself.

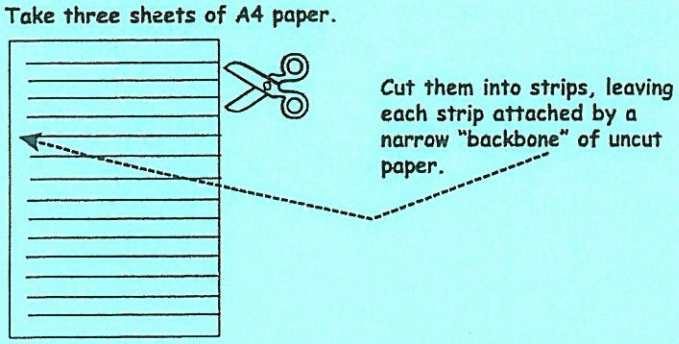
The result of a brainstorming session should be a long list of ideas. Sometimes it is difficult for the human brain to comprehend and process too many bits of information. Research shows that the human brain can only comfortably process about 7 bits of information at a time. However, if you can *cluster* or *group* bits of information, the total number of categories is smaller, enabling the human brain to better process the information. It can therefore be useful to "chunk" information (put it into clusters or groups).

The suggestion on the following page can help people to brainstorm and sort ideas into groups, as part of one activity.

Brainstorming and sorting of ideas

Step One: The brainstorming

- Prepare some paper strips for the learners to record their ideas on. To make the paper strips in a way which is easy to handle, cut them so they remain attached to each other by a narrow strip of uncut paper, as shown in the diagram.



- Instruct the groups to brainstorm as many ideas as they can, using the DOVE rules for brainstorming. They should write each idea on a strip of the paper.
- It is not easy to do the sorting unless learners have a long list of ideas, so give ample time for the groups to generate ideas.

Step 2: Sorting and grouping of ideas

- Explain to the learners that dealing with long lists of ideas can be overwhelming for the brain, so they need to group ideas. By clustering information it is much easier for the brain to handle the information. It is less overwhelming and intimidating.
- Ask groups to tear the "backbone" of their list so each idea is on a separate strip of paper.
- Instruct them to clear a large surface to work on (e.g. a table, with all other objects cleared off it).
- Ask them to sort the strips into piles of similar ideas. They should move the strips around on the table top, until they are happy with the way they have sorted their ideas. All the time they should be discussing the clustering with members of their group.
- Next they should look carefully at the ideas in each category. If the category is large it is very likely they could sub-divide it into two or more sub-categories.
- Next they should take some blank strips of paper and write a NAME for each of their categories and sub-categories. Arrange them on the table, around their main topic or question.

Step Three: ***Making a permanent record of their ideas***

- There are two ways they could do this - either as a hierarchical list (with indented sub-categories) or as a mind-map.
- Do not re-write the ideas. Simply arrange them on a large sheet of paper (e.g. an A3 sheet) and stick them on with sellotape.
-



Add any additional notes of your own here.