

INVESTIGATING SYSTEMIC FACTORS AFFECTING
SCIENCE LEARNING IN CURRICULUM 2005 :
CASE STUDIES OF TWO SCHOOLS

by

WARREN GEORGE WILKINSON

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Supervisor:

Dr Jaap Kuiper

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Abstract

The thesis illustrates the contention that an outcomes-based system with its underlying philosophy of social constructivism cannot operate effectively within a traditional school system. Restructuring of an institution is necessary to accommodate the outcomes-based system. Using the research instruments of interviews, questionnaires, journals, participant observations and collection of physical artefacts, two case studies investigating systemic factors as they influence science learning were conducted in two South African schools. The one school, St Sebastian's College, was an extremely well resourced school while the other, Mtunzini High School, was a middle class school in comparatively deprived circumstances. Attempts were made to introduce an outcomes-based education course involving a group of grade 8 learners in the respective schools. Difficulties in implementation were encountered and at best only very limited success was achieved. There were two reasons for this. First, particularly in the case of St Sebastian's College, I designed a course which was over ambitious in that it was not suited to the developmental stage of the learners. Second, traditional schooling systems follow a perspective of education termed 'the structure of the disciplines' which fosters a system of rigid time tabling, compartmentalisation of subjects and emphasis upon summative assessment. In contrast, the curricula I designed involved a 'cognitive' perspective which required flexible time scheduling, integration of subjects and developmental assessment. The conflicts which arose include time constraints and resistant attitudes on the part of learners and teachers. The thesis culminates with some suggested steps to follow should a school community wish to restructure. These include a shared vision, employing organised abandonment, capacity building and commitment to a systemic perspective.

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Last and perhaps most significantly, I wish to avail myself of this opportunity to thank my parents, not only for their support rendered during the writing of this thesis, but also for their contributions and sacrifices made towards my education over many years.

Dedication

Dedicated to:

Mrs Sally-Ann Robertson, Professor Pat Irwin and my mother without whom this thesis would never have been possible.

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Chapter 1 : The Literature Review

1.1. Introduction

There is, on the whole, nothing on Earth intended for innocent people, so horrible as a school. To begin with it is a prison, but in some respects more cruel than a prison.

I encountered words to this effect by G.B. Shaw in a JMB English Composition Examination many years ago and subsequently have never forgotten them. I concur wholeheartedly with Mr Shaw when considering a traditional school.

South African schools are currently facing the challenge of implementing Curriculum 2005 and more specifically Outcomes-Based Education (OBE) which is a clear paradigm shift away from the traditional schooling philosophy. Since I had my reservations concerning the rigid programmes of traditional schooling, I decided to conduct research to establish whether or not traditional schools were structurally prepared and their personnel attitudinally attuned for the transition.

Since this is a qualitative piece of research, I consider it essential to nail my colours firmly to the mast and inform the reader of my central assumptions. While conducting fieldwork at the respective venues, I assumed that the traditionalist schooling system is incompatible with the fundamental changes which must accompany OBE. This, in my view, is the case because the major role players, be they educators, administrators or learners, at the two research sites, seemed neither to have the will nor the structure to support these changes.

In the first chapter of my thesis I will explain the rationale motivating the introduction of OBE as an educational policy in South Africa. As part of the explanation, I will inform the reader of the key educational assumptions of OBE and why it is regarded by scholars as a paradigm shift away from traditional thinking. I will then explain the implications of these premises for a school. This is important since it not only offers the reader some insight into the differences between the two genres of education, but also warns of the difficulties which arise when making the transition from a traditional school to one based on OBE principles.

1.2. The “Paradigm Shift”

Ever since my interest in curriculum studies began with the mention of Outcomes-Based Education (OBE) and Curriculum 2005 I have been hearing and reading about the terms “paradigms” and “paradigm shift”. Even when conducting my fieldwork, teachers spoke freely of the two terms. Yet, no one seemed able to articulate the exact origin and meanings of these terms.

Boyd (1992:506) defines “paradigm” as a model or theory where they consciously or unconsciously guide our thinking about such things as organizations, leadership, and policy.

The term “paradigm shift” is mentioned by Finn (1990 585-586) with reference to Thomas Kuhn’s famous book, *The Structure of Scientific Revolutions* (1970: 2nd ed). Kuhn used the term “paradigm” when explaining the way the world was perceived to operate by previous generations of observers, and how scientific revolutions altered these perceptions. Among the historic “revolutions” in science were the change from the Geocentric universe of Ptolemy to the Heliocentric version mapped by Copernicus, the change from Newtonian mechanics to the quantum theory of Planck and Einstein and the change from the teleological notions of evolution to Darwin’s theory of natural selection.

Finn hastens to add that the revolutions in science do not alter phenomena themselves, but rather the ways they are viewed. Take the Copernican revolution, for example. Copernicus saw the same sun, moon and planets as Ptolemy, but the interpretation of their movements in relation to one another were completely different.

In the same way that scientists interpret physical phenomena in different ways than previously perceived so educators have applied the term “paradigm shift” to education. Finn (1990:586) describes traditional education in terms of emphasising inputs, namely, process and system, effort and intention, investment and hope. To improve education means to try harder, to engage in more activity, to give people more services, and become more efficient in delivering them.

The educational paradigm shift, argues Finn (1990:*ibid*), has been recently defined as a change in emphasis from inputs to outcomes. Sure enough, just as in the Copernican

revolution, the phenomena have not changed only the interpretation thereof. In the educational sense, there are still teachers available to teach and learners who wish to learn. However, education according to this new definition is the result achieved, the learning that takes place when the process is successful. Only if the process succeeds and learning occurs will we say that education happened. If there is no evidence to verify such a process then no education occurred – however many attempts were made, resources allocated or energies expended. In short, it does not matter from an outcomes perspective the time spent in the classroom studying courses. What is ultimately important is can the student successfully demonstrate proficiency.

1.2.1. Reasons for this paradigm shift

The question foremost in my mind is why change the emphasis from “inputs” to “outcomes”? What possible reason(s) could there be for rocking the boat to the extent that major restructuring of education needs to be effected?

I will argue that there are essentially three reasons for this change in emphasis. The first is based upon research, the second is wider economic and social forces exerted upon schools, while the third is the inefficiency of traditional schools to meet the needs of the individual learner.

1.2.1.1. Research that weakened the link between inputs and outcomes

Finn (1990:589) makes the point that there was once a very robust connection between educational inputs and outcomes. For example, education once presumed that by making substantial investments in resources to begin with would automatically be proportional to profitable dividends. However, a comprehensive study of educational “productivity” by Herbert Walberg (nd) as quoted in Finn (1990:589) revealed that some educational methods worked far more effectively than others, irrespective of the cost.

Walberg’s work was bolstered by the synthesis and meta-analysis of many studies by Eric Hanushek (1989) as quoted in Finn (1990:589) which weakened the link between educational inputs and outputs even further.

In addition to the research which weakens the link between inputs and outcomes, there are wider economic and social forces being exerted upon schools to change their emphasis. I will now continue to elaborate upon these factors.

1.2.1.2. Economic and social forces exerted upon schools

See (1994:30) claims that there have been four information revolutions in world history, namely, the storytellers, the scribes, the printers and most recently – the digital revolution, described as the “Fourth Information Revolution”. This is the age in which schools and society are presently located. All forms of information have become digital and learners can use technology to gain access to information at any time, from any place in the world, in any format required. Darling-Hammond (1990:286) supports See in his claim and she notes that in economic terms, the world is moving from a manufacturing economy to a technologically based information economy in a global market place. Darling-Hammond continues to argue that the traditional form of education supported academic success for some and failure for most others. The majority of failures then found employment on farms or in factories since the manufacturing economy was reliant upon low-skilled workers. Although this type of economy is redundant in the western world, schools still function to support it. In South Africa, which is a developing country, schools, in my opinion, are also guilty of producing a high failure rate among its learner population. This can no longer be countenanced for the South African economy is in desperate need of learners, subsequently to become workers, who require a more advanced knowledge of technology and industrial developments. This is a key requisite to remain competitive with other countries in the global market place.

Pearce *et al* (1992:7) refer to McNeil’s (1990) four orientations of the curriculum. These include the humanistic, the social reconstructionist, the technologist and the academic approach. It is my opinion that South African schools have been compelled over the decades to adopt this academic approach. This is the vehicle by which learners are introduced to subject matter disciplines and organized fields of study, such as Geography, Science, History and Mathematics. Cohen (1993:791) identifies the key problem with this approach in traditional schools, namely, that learners are not taught to inquire, but rather to digest the results of other people’s inquiry. Furthermore, Cohen (1993:729) adds that current assessment methods focus on the most superficial methods of learning such as memorization of facts. Learners are rarely exposed to the necessity of making major value decisions, solving real-life problems or taking intellectual and practical risks.

Darling-Hammond (1990:289) corroborates this and draws upon the comprehensive study of more than 1,000 classrooms by John Goodlad. He found that for the most part, the curriculum called for and made appropriate only some ways of knowing and learning and not others. He found that students listen, read short sections in textbooks, responded briefly to questions, and took short answer and multiple-choice quizzes. They rarely planned or initiated anything, did not create their own products, never read or wrote anything substantial and did not engage in analytic discussions. The results are summarised by See (1994:30) who claims that schools in contemporary times are mere sorting and assessing systems rather than teaching institutions. Consequently, only a minute proportion of learners are destined for the professions, while the majority are sentenced to low-skilled employment or more likely in South African terms – unemployment.

By way of contrast what does business and industry require of its students and future employees? To gain a better perspective on the matter I urge the reader to consider closely the requirements of William Hayes, a senior staff administrator at Honda of America in Maryville, Ohio.

Hayes (1994:42) mentions first of all, that students coming into the Honda workplace must be able to function as part of a team. They need to be able to build trust, understand diversity, share effort and accept responsibility. This point is particularly acute in South Africa with its concerted moves away from Apartheid and repression to a liberal democracy where diversity is the norm in the workplace and in society. Second, students must be able to communicate effectively. Third, in addition to good verbal skills, students must write adequately to compile reports, send memos or submit suggestions. Fourth, students must have good presentation skills. This means they must explain possible solutions in the form of charts and graphs. Fifth, students are to be effective problem solvers. No longer is there the convenience of a plant “expert” to solve problems, but rather a team is to be responsible for finding solutions systematically by gathering data and deciding on a solution.

In comparing Cohen’s and Darling-Hammond’s opinions about schooling with the requirements of business and industry, one immediately notes the vast chasm between the reality and the ideal.

Barnes (1993:3) quotes King & Evans (1991) as asserting that public education must improve and that dissatisfaction with the poor results of educational practices is the major impetus for outcomes-based education. Proponents such as O'Neil (1992), as quoted by Barnes (1993:4), believe that implementation of OBE will result in long-needed changes in education. Barnes further quotes Finn (1990) who suggests that these changes in education are possible if educators shift from the old paradigm of education which focused on inputs, to a new paradigm stressing outcomes.

DIRECT COST TO THE PROVINCES OF CANDIDATES WHO FAIL THE STANDARD 10 EXAMINATION			
Province	Failed candidates	Direct unit cost	Total cost
Eastern Cape	41 899	R387	R 16 214 913
Free State	23 083	R390	R 9 002 370
Gauteng	36 702	R312	R 11 451 024
Kwa Zulu-Natal	48 975	R463	R 22 675 424
Mpumalanga	20 498	R390	R 7 994 220
Northern Cape	2 760	R384*	R 1 059 840
Northern Province		R350	R 30 397 150
North West	24 285	R305	R 7 406 925
Western Cape	8 816	R480	R 4 231 680
TOTAL	293 857		R110 433 547
• This is an average cost as no information was available for the Northern Cape Source: City Press 9.2.98			

Table 1.1
[Source: Edusource Data news (21):July 1998:11].

1.2.1.3. Reasons for restructuring schools : Organizing for results

Up to this stage I have quoted research that exposes the tenuous relationship between inputs and outcomes and that current traditional schooling systems are completely out of sync with the social and economic trends. If, however, educators are to be convinced that their

institutions are in need of restructuring and their teaching methods are in vain, then more evidence needs to be brought to the fore to expose the shaky foundations of traditional schooling. The success or failure of the existing traditional schooling system in South Africa rests upon the Matriculation Examinations. As a case in point consider Table 1.1 detailing the high numbers of failures of candidates and the corresponding costs.

The president of the National Professional Teachers' Association of South Africa (NAPTOSA) as quoted in Shindler (1998:11) declared that the direct cost to the department of the 293 857 pupils who failed the 1996 matriculation examinations was an estimated R110,4m. He further speculated that R750m would be required to accommodate the failed candidates who were to be readmitted in the 1997 academic year.

In my opinion, the current system is not only unsatisfactory because of a high failure rate and high financial burden, but, what is worse, is the "inputs" traditional system lacks credibility. In the same article in February (1998:10), it is reported that the Education portfolio committee received confidential information regarding the assessment of the 1996 matriculation examinations. The import of this was the results were highly adjusted to assist disadvantaged pupils. Take the example of the Eastern Cape: All had to be raised, a third by 9%.

It is my belief that in terms of education the origin for the poor results, high numbers of failures, exorbitant costs and consequent lack of credibility lies in William Spady's (1988: 4-5) denunciation of the traditional schooling system. His argument is supported by the research of Benjamin Bloom (1976), John Carroll (1963), Robinson (1985) and Brown & Saks (1975, 1978, 1980, 1981, 1983, 1984, 1987), as quoted in Schalock *et al* (1993:181).

1.2.1.3.1. The contention of William Spady

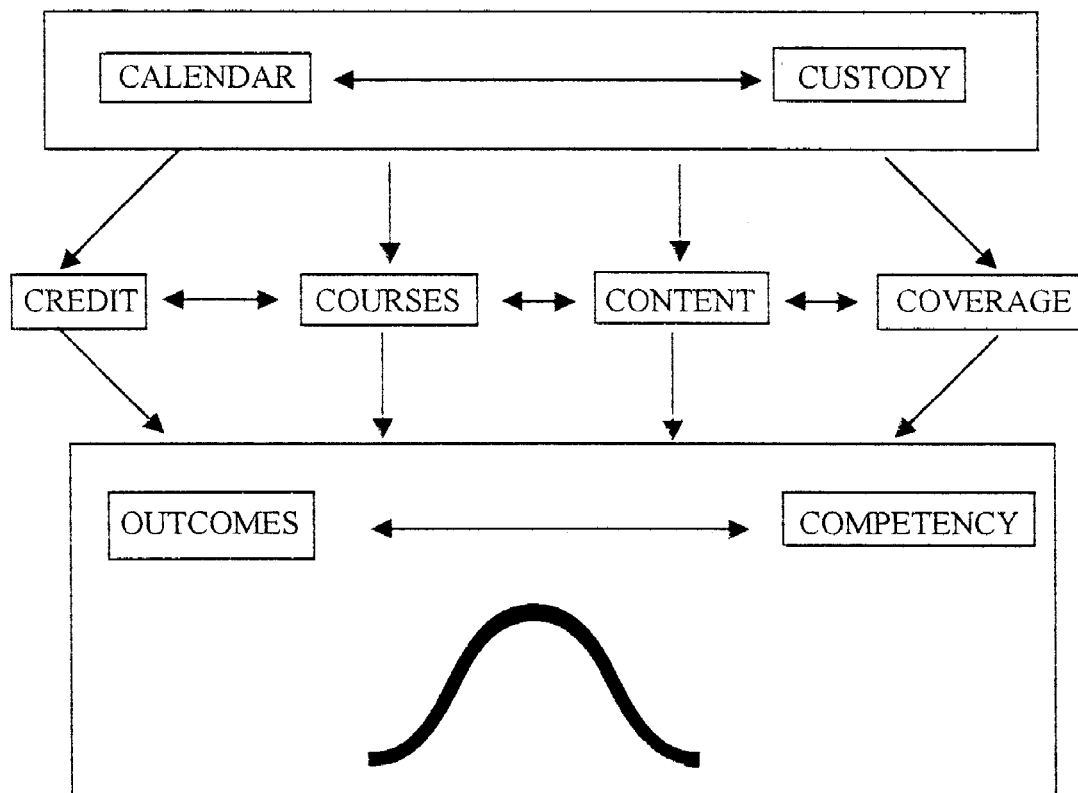
Fundamentally, Spady (1988:4) asserts that the 'traditional schooling system' is not organized for results but for student custody (ie promotion and retention of students), administrative convenience and for time management.

In traditional schools, it is the calendar with its servants the clock and timetable which exert the pervasive influence on the organization of schools and on the thinking of those who work and study in them.

Parkyn (1994:35) describes the characteristics of the traditional schooling system. At the start of a school year, a teacher is assigned a class with a brief to cover a certain syllabus in the one year period. A certain number of periods of fixed time duration are scheduled each week in which the teacher and pupils come into contact. In such a scenario, ability ranges in the class generally tend to vary from poor to excellent, but each learner is usually granted only one chance to write a test or examination. The results in the class vary, usually in correspondence to ability range. Some students, mostly the brighter ones, are deemed to be more competent and have lived up to the expectations of the teacher. The less competent ones score lower marks in not meeting the requirements of the course.

Consider the diagram:

The prevalent practice paradigm



Spady (1988:5)

Figure 1.1

Even though a student may be functioning at a higher level than his class mates, he is not permitted to study more difficult work while his weaker peers receive remediation to solve their conceptual confusion. The key issue for the teacher is not to meet the needs of the individual learner, so that each can reach maximum potential, but to engage in what Spady (1988:5) calls the unproductive syndrome of “putting in time” and “covering the material”. The net result is all the students, irrespective of ability are retained until the year’s course is complete and a wide range of competence and outcomes are exhibited. This is illustrated by the normal distribution curve at the bottom of figure 1.1.

The circumstances in traditional schooling arise because time is set as the constant. Spady now recommends that time should become the variable. Learners are to be given extra time and support in their efforts to achieve success. However, at the end of the educational encounter, all roads would lead to Rome and everyone would be able to achieve success. This is the essence of what Spady calls organizing for results.

1.2.1.3.2. The research evidence in support of Spady’s claim

The research evidence upon which Spady’s argument rests is expounded first of all by Benjamin Bloom (1976) and Robinson (1985), as quoted in Boschee & Baron (1994:195). According to Bloom and Robinson every child, when given sufficient time and proper assistance, can be expected to learn. In support of this, Carroll’s (1963) research, also quoted in Boschee & Baron (1994:195) shows that differences in student scores on aptitude and intelligence tests are measures of *time required* for different students to learn the same material, not as previously believed, measures of students’ *innate capabilities* to learn. Brown & Saks, quoted in Schalock *et al* (1993:181), contribute their research findings to confirm the work of Carroll, Bloom and Robinson. They found that additional levels in outcomes can be expected from additional amounts of time allocated.

This gives rise to Spady’s suggestion, quoted in Artis (1994:27) that, “when students learn and whether they learn well is more important than when and how they learn it”.

I will now consider a new paradigm, a new interpretation of education that will ensure maximum benefit for all students enrolled in the schooling process. It contains all the

elements of the prevalent practice paradigm, except outcomes and competency have been exchanged with time and custody. This is now the outcomes-based paradigm wherein the outcomes of a person's learning and the level of achievement are decided upon before any further course design is considered or supplemented. What varies, is the time taken for each individual learner to achieve those outcomes and consequently how long each person will be retained at a certain level before promotion, as quoted in Spady (1988:5).

Consider figure 1.2 (Spady (1988:6)).

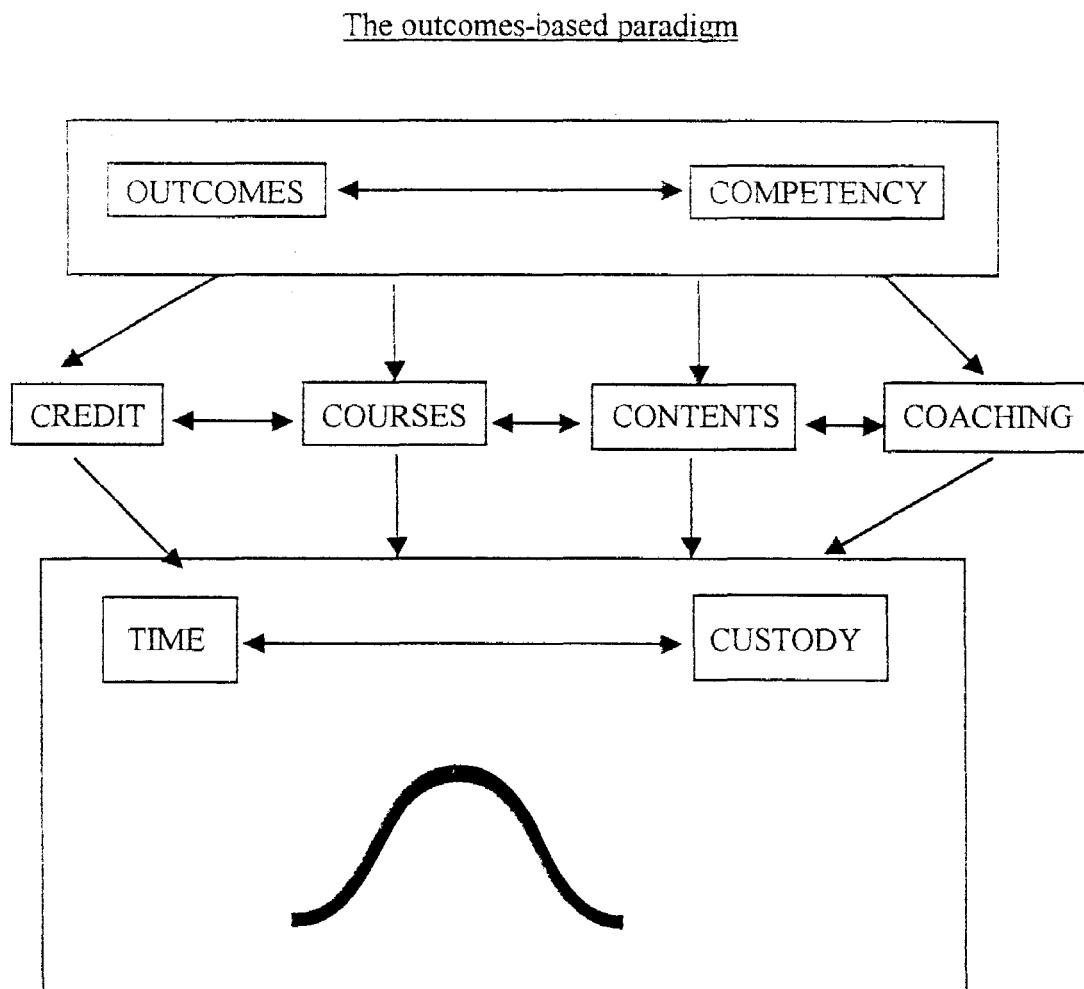


Figure 1.2

The result for curriculum planners, explains Spady (1988:7), is that broadly defined exit outcomes are decided upon and then planners design *down* for the thematic programmes that support them. More will be said about this design process later in the thesis.

Suffice it to say at this stage that I have considered three key reasons for questioning the creditability of traditional schooling. First, the tenuous link between inputs and outputs according to the research of Walberg and Hanushek. Second, the observations of Darling-Hammond and others who doubt the efficacy of schools to meet the challenges of a global economy and the Information Revolution of the 21st century. Third, the erroneous perception that schooling should be organized according to custody of students and the calendar with its adjuncts – the clock and timetable which was proved to be based on faulty premises by the research of Bloom, Carroll, Robinson and Brown & Saks.

These are all serious indictments which cannot be summarily dismissed and are greatly accentuated since South African society is currently in a process of social transition within the new dispensation of a liberal democracy. Unfortunately, the country is having to cope with severe social problems. These include high unemployment and deeply ingrained racism. Considering unemployment, Reuters (quoted in the EP Herald, p.3 29th August 1998) quoted a figure of between 23% and 30% in the formal sector. Concerning racism, Edusource (Data news No 21/July 1998) refers to the Human Rights Commission (HRC) as having investigated 29 cases of alleged racism in schools in 6 provinces since 1995. A particularly severe case, which was well publicised in February 1998, occurred at Vryburgh High School after the governing body suspended 5 black children from school. It developed into a conflict involving black and white parents and the community at large. A task team appointed by a multi-party parliamentary committee resolved the conflict after exposing deep-seated racism in the school. Furthermore, Spargo (1990:30) cites problems of a growing population and increasing urbanization with perils of malnutrition, spread of disease and a deteriorating natural environment.

In addition, McKernan (1993:344) alerts us to the fact that a high-tech culture prevails in the west and learners will need to compete in the arena of global economic warfare. Since skill requirements in the workplace changes five times faster than organizational changes in schools, learners will need to become adept problem-solvers and independent learners.

To make a contribution to meet these challenges, National Education is implementing Curriculum 2005 and more specifically outcomes-based education in government schools. It

is this form of education which deserves closer scrutiny in terms of its philosophy and basic premises and the consequences thereof for schools and the communities which they serve.

1.3. Outcomes-Based Education (OBE)

1.3.1. The philosophy of OBE

Rogers and Dana (1995:7) state that “outcomes-based” refers to the results that the education community desires before teaching occurs. Geddert (1993:205-6) contends that to decide upon these desirable qualities in terms of what a learner should know, do and be like, the entire community needs to engage in meetings and conversation. To ensure that no misunderstandings concerning OBE arise, school administrators need to adhere to this central tenet of broad community involvement. The school educators, parents and community members must all be willing to build trust and improve student learning. Once decisions concerning exit outcomes and appropriate means to assess performance have been made then appropriate instructional strategies and learning activities need to be implemented to achieve the desired outcomes.

To understand this policy of total community involvement in selecting exit outcomes and then designing backwards to achieve the outcomes as opposed to following syllabi perhaps it is appropriate to present an analogy of sharecropping described by Fritz (1994:80).

The traditional system of schooling is akin to plantation slavery which is input-compelled. Under such a system, the slave owner makes the daily farming decisions. In sharecropping landlord Legree compels outcomes, not inputs: “Johnny, you make your own decisions about planting, weeding and harvesting. I’m deciding only the outcomes: Your family delivers eight bales to me by November 1 each year. This is a “high-stakes” outcome because if you fail, I will punish you by taking away your home and means of feeding your family.”

In this analogy, the landlord is the National Education Department who decides upon the outcomes and Johnny is the school teacher who can conduct any course he likes, but must do so in such a way that the learners exhibit the intended outcomes desired by National Education.

To expand on this point, OBE is often misunderstood by interested parties because it cannot be defined as strategies, content, curricula, facilities, staffing or budget. Instead it is really a

philosophical “umbrella” over these operational aspects of education. It is the responsibility of each education community to determine how strategies, content, curricula, facilities, staffing and budget will be structured to implement the OBE philosophy.

The basic premises of the OBE philosophy are defined by Spady & Marshall (1991:67):

- (i) all children can learn (perhaps not in the same way on the same day),
- (ii) success leads to more success, and
- (iii) schools are a key element in providing the conditions for success.

These basic premises may seem very attractive, but if complied with serve to re-define education and have far reaching consequences for the community. Rogers and Dana (1995:8) mention a few important implications:

1. The education community (school and community it serves) must be involved in education decisions.
2. It involves the entire education community in major curricula decisions and will take time and must be done well in order to build trust. Pliska (1997:5) and Evans & King (1994:15) speak of a total systems approach for change to be successful. Any piecemeal efforts are doomed to failure. Mike Cohen (former education program director of the National Governors’ Association) quoted in Brandt (1991:55) agreed with Pliska and Evans & King arguing that all aspects of restructuring a school are interrelated. For example, assessment cannot be thought of independently of accountability. More than this, accountability needs to be related to the curriculum and to alter a curriculum the culture *inside* the system needs to be altered. Cohen concedes that all these factors cannot be accomplished simultaneously, but must be thought of concurrently.
3. Change will require training and resources, and districts must be prepared to operate in old and new ways simultaneously until change is complete. David (1991:15) sympathizes with teachers who are tackling the task of restructuring schools. She refers to their situation as being “caught in a time warp between the old and the new”. On the one hand, teachers are being asked to teach their students to think – to forsake superficial coverage of content for depth and understanding. On the other hand, they are still judged publicly and privately by standardized tests that emphasize isolated facts, rote learning and content coverage.
4. Focus to be on local results, and not on what other communities have done or experienced.

The key issue is the entire school community is to be involved. In past years, school administrators made decisions and then informed the scholars and the community after the event. Parents, having real and important desires for their children, were ignored. This cannot be allowed to continue, for teachers and administrators are to acknowledge that parents want their children to:

- (i) learn the subject matter,
- (ii) become self-directed learners,
- (iii) learn how to work well with others,
- (iv) be effective communicators,
- (v) develop responsibility, and
- (vi) apply what they learn in new situations.

Traditionally, schools have concentrated upon number (i), learning the subject matter. As we approach the 21st Century, parents and business require that learners master the other five as well. Friedland (1992:97) supports this viewpoint stressing the need to move away from existing outdated curricula because students of today are of a different era with significantly different needs. Since schools have more autonomy in deciding on how to achieve these outcomes, it is crucial that all stakeholders participate in developing educational outcomes that will result in learning. So what are outcomes? Spady *et al* (1994:29) clarify that outcomes are clear, observable demonstrations of student learning that occur after a significant set of learning experiences. They are not values, attitudes, feelings, beliefs, activities, assignments, goals, scores, grades, or averages.

It must be remembered that OBE is a vision still to be realised and schools at the present time are grappling with concrete issues such as low budgets, teacher strikes and redeployment of teachers. For this reason, change will take time and is an on-going process with growth being continuous. This viewpoint of Rogers & Dana (1995:9) is well supported by McNeir (1993: 23-24) who writes: "Schools must allow enough time to carefully plan their program and to evaluate its results. The vision of restructuring offered by the OBE model must be sustained if it is to truly transform." Most likely, OBE efforts by communities will concentrate upon what is no longer satisfactory, what needs to be done in its place, and hold everyone – teacher and learner – accountable for what they do. This notion of accountability is affirmed by Finn

(1990:590) whereby teachers in an OBE system acknowledge the relationship between what goes on in formal education and the learning which results.

To successfully implement OBE the educational community needs to develop systematic long-term plans to reach community held educational goals. If a community opts for a programme to secure short-term success without a systematic plan then the result will be disillusionment, outright anger and suspicion of the OBE movement.

Not only must plans be well thought through and systematic, but each community is to develop its own goals and plans. This is the case because there are many different ways to implement OBE.

I will now consider the fundamental premises of OBE and their implications for existing schools.

1.4. The fundamental premises of OBE and their implications for schools

In this section, I plan to closely analyse, in turn, the three premises of OBE to establish their meaning. After each premise I shall consider the consequences for the teaching and learning community of schools.

1.4.1. Assumption I

Spady *et al* (1994:30) state the first key assumption of OBE as follows:

All students can learn and succeed, but not necessarily on the same day or in the same way.

These authors (*ibid*) then succinctly clarify what teachers are to focus upon when faced with a class of learners. Teachers are to be cognizant of a student's unique learning needs, rates and characteristics. Smith (1995:24) justified this clarification with the observation that the traditional system is a single entrée educational menu for all children. Yet, in aiming a course at the general ability range in a class, the learning environment may fail to address the needs of certain individual learners. The reason for this, continues Smith (*ibid*), is because children and adults learn at different rates, in different ways, and at different times. For this reason, no single profile of a developing person is identical to another, nor are one's strengths, interests, or talents the same..

The consequence of Smith's recognition that all learners are different is explained by McGhan (1994:71). He believes it is crucial to realise that students in an OBE system, who progress through a given set of outcomes at different rates, can only be accommodated if schools learn to handle scheduling problems. This is the case, because students will invariably start and end outcome sets at different times.

Moody (1994:35) provides one with a deeper insight into what "scheduling problems" actually means. He envisages that ringing bells will no longer separate classes into 50-minute blocks of time fragmented from one another. It is incumbent upon teachers and the administration to restructure schedules and calendars to provide longer blocks of time during which more in-depth learning can occur.

Moody speaks of longer blocks of time. My immediate question is if 50-minute periods are no longer suitable, then what duration would be more appropriate? Arbor (1990:8) suggests that schools should be utilised year-round; open each day from early morning until evening. She suggests scheduling sessions for three or four hours at a time when teachers and students are to meet.

Time-tabling changes, although a fairly routine undertaking in a time-based traditional school proves, in an OBE-framework, to be more than a match for even the most ardent of administrators. Take the example of Larry Nyland, the Superintendent, Pasco, Washington, USA, School District No 1. Nyland (1991:35) cites time-tabling as one of the most demanding of challenges in the district. Both seniority of individuals and tradition had to be set aside to cope logistically and emotionally with the obstacles which beset the reforms.

Spady *et al's* (*ibid*) first philosophical premise also claims that students not only require varying amounts of time to master a unit of work, but also vary in their learning styles. Rosenthal (1996:87) lists five different kinds of learning styles, namely: visual, auditory, tactile, kinesthetic and mapping. It appears to me that the traditional form of schooling with its emphasis on content coverage favours the auditory learner. This is so because, for the most part, the teacher lectures the class for much of the time compelling students to listen attentively. In the South African context this is particularly undesirable in my opinion because it limits English second language learners who constitute the majority of the population. I agree with Reid, quoted in Rosenthal (1996:96), who demonstrated that English

second language learners are more tactile and kinesthetic (building of models) in terms of their preferred learning styles. For this reason, the first philosophical premise of OBE, expounded by Spady *et al* is particularly appropriate. Teachers are duty-bound to accommodate the learning styles of learners.

In order to best assist learners according to their most favoured learning styles, the implication here is a change in teaching methodology. Kgame (1997:8-9) refers to what she describes as a participatory methodology. Examples of this methodology include role play, discussion, brainstorming and pair and small group work.

To further my analysis of the first premise of OBE expounded by Spady *et al (ibid)*, I will now continue with a discussion of mastery and cooperative learning as related issues pertaining to students who do not learn “in the same way”.

Evans & King (1994:13) acknowledge that although OBE does not require mastery learning as an exclusive instructional model, many authors consider mastery learning to be an integral part of OBE beliefs and practices. These authors include Burns (1987), Schleisman & King (1990) and Spady (1982), as quoted in Evans & King (1994:13). Guskey *et al* (1991:37) inform the reader that mastery learning, developed by Bloom in the mid-1960s, is a process by which aspects of individualized instruction improve student learning in group-based classrooms. What follows is the process which teachers will be expected to apply.

The material to be learned is divided into instructional units. Following teacher instruction after each unit, a formative test is administered. This is not for final mark purposes, but it provides teacher and learner with feedback on whether or not successful learning was achieved. If necessary, corrective activities are to be provided requiring additional time and practice until mastery is achieved. For those who achieve mastery first time round, they will be given enrichment activities. The weaker learners, after corrective measures, will then perform a second formative assessment task before going on with the next unit.

Guskey *et al (ibid)* state clearly that corrective activities are individualised and target concepts and skills learners have not mastered. These activities which very often require peer cooperation demonstrate a more appropriate learning approach.

Allied to mastery learning is the use of cooperative learning. Guskey *et al (ibid)* envisage that learners are to work on assigned tasks in small heterogeneous groups of two to six learners. The group members, while engaging in the activity, are to collaborate and mutually support one another. Johnson & Johnson (1987, 1989), as quoted in Guskey *et al* (1991:37), provided five elements crucial to any cooperative learning programme. These include:

- (i) Positive interdependence: Learners evidence responsibility for their own learning and that of other members in the group.
- (ii) Individual accountability: Each learner is to demonstrate mastery of the assigned work.
- (iii) Face-to-face interaction: Each learner is to explain concepts in their own words and in the process assist each other towards an improved construction of knowledge.
- (iv) Social skills: Learners are to interact in a positive manner. This means that each member received an opportunity to communicate and contribute ideas and support under the effective leadership of a particular group member. The atmosphere is to be harmonious and cordial.
- (v) Group processing: Groups are to assess effectiveness and devise ways to improve.

My first reaction to mastery and cooperative learning is that they both sound impressive, but do they assist students towards success even if it is not in the same way, on the same day?

Guskey *et al* (1991:38) referred to Thorpe Gordon Elementary School in Jefferson City, Missouri, which implemented OBE with emphasis on mastery and cooperative learning in the late 1980s. Some excellent results were recorded. The third graders wrote the criterion-referenced Missouri Mastery Achievement Tests. In 1989 only 10% of the third graders scored between 20-40%. More significantly, 70-90% were ranked between 60-100% with 50-75% of these achieving over 80%.

The evidence of Thorpe Gordon is not isolated. Evans & King (1994:13) refer to the meta-analysis of a mastery learning study conducted by Kulik & Bangert-Drowns (1990). These researchers examined 108 studies on Bloom's Learning for Mastery and Keller's Personalized System of Instruction. The meta-analysis indicates that the average student in the mastery learning class performed at the 70th percentile, whereas the average student in the

control class performed at the 50th percentile. Furthermore, the mastery learning approach favoured lower-aptitude students more than higher-aptitude students. The downside, it seems, is that students in mastery learning classes complete fewer courses than in control classes. This is what I would expect logically, because the Spady *et al (ibid)* premise demands that *all* learners are to succeed. Hence, more and more time is to be made available until learners can demonstrate mastery.

It appears from this evidence that mastery learning and cooperative learning really favour the weak learner, but what can be said from a teacher's perspective?

In a paper written by Kuiper & Wilkinson (1998:10), I explain my previous teaching methodology before enrolling for a B.Ed course at Rhodes University. It was my practice to afford Engineering Science students the opportunity to transcribe pages of laborious notes which I had prepared for them on overhead transparencies. This served as a "delaying tactic" so they would have something to do. In contrast, when I contemplate the possibilities of mastery and cooperative learning explained earlier my mind-set and experience from a teacher's perspective is that it must be very taxing. I make this statement because South African classrooms are generally (though not always) overcrowded and in some cases are occupied by learners of diverse cultural background. Hence, to keep pace with each individual's learning needs through a system of feedback and correctives, monitored through collaboration and group work is laudable in theory, but not easily achieved in reality. I hasten to add that the OBE ideal is not impossible because Artis (1994:29) lists a few examples where OBE has been implemented successfully. These schools and districts include:

- ◆ Public schools in Aurora, Colorado,
- ◆ Township High School District 214 in Arlington Heights, Illinois,
- ◆ Johnson City Schools in Johnson City, N.Y.,
- ◆ Lucia Mar Unified School District, Arroyo Grands, California, and
- ◆ The College Community School District in Cedar Rapids, Iowa.

Be that as it may, to illustrate the difficulties of mastery and cooperative learning as teaching and learning strategies necessary to achieve a high success rate of students, I will now draw

upon the high school experience of Lee Ann Cavener, quoted in Schwarz & Cavener (1994:330).

Lee Ann was an English teacher at Ponca City High School in 1992-93 and worked in conjunction with a university professor, Gretchen Schwarz. Cavener cited time for grading and regrading *and* further planning as the main difficulty in the transition to OBE. It was found that more than half the class did not meet the 70% criteria for a mastery learning assessment on a literature concept. The result was more extended teaching of new concepts and more testing of old concepts. Cavener was then waylaid by more assessments of the new and redone work. She tried to assist learners with extended deadlines, but concludes that the paper work and record keeping became a formidable burden.

Another danger of OBE alluded to by Schwarz & Cavener (1994:331) was that students translate the OBE premise of “success for all” into the practice of postponement. The idea being that if they do not have to pass initially then delay, gain insight into the questions posed, and use these as cues for the test to follow. Furthermore, teachers struggled mightily to cope with the learning styles and ability ranges of learners. To remedy this, perhaps a computerised system is necessary. I will now explore this possibility.

1.4.1.1. Computer Management Systems

To effectively track the achievement of a large number of students both Nelson (1985:15) and Capper and Jamison (1993:442) refer to a computerised information management system. The purpose of this is to remain consistent with the mastery learning philosophy of not allowing students to advance before a prerequisite skill is mastered. See (1994:31) advises teachers that in addition to managing assessment records, computer programmes are useful in determining an individual’s learning style. He recommends products such as *ROADMAP Learning Styles* software which ascertains a person’s preferred learning style and assists teachers towards designing appropriate individualized instructional activities.

In Cavener’s case, as quoted in Schwarz & Cavener (1994:333), declining financial support for schools meant that no computers were made available to assist in record keeping and test design. In South Africa, many schools will be in similar financial circumstances and the

absence of computers will place extreme pressure on teachers. I will have more to say about the use of computers in my two case studies.

1.4.2. Assumption II

Spady *et al* (1994:30) state the second key assumption of OBE as follows: "Successful learning promotes more successful learning".

When I first read this assumption that success breeds success, I was quite puzzled, asking myself why make this fundamental assumption? How is it related to a child in a school? Friedland (1992) explains as follows:

Friedland (1992:96) quotes social scientists whose contention it is that children are growing up in the most negative, problematic and neurotic society ever. It is believed that these circumstances must have a detrimental impact on a child's self-esteem. Consequently, students exhibit distorted values, lack of discipline and have fuzzy goals. All this translates into low interest, low motivation and low achievement.

Friedland (1992:97) speaks of reputable research studies which show a high correlation between healthy esteem and success at school in the areas of higher educational aspirations and superior academic achievement among others. Purkey, as quoted in Friedland (1992:97) comments:

There is a significant and positive relationship between a student's concept of himself and his performance in school. Students who feel good about themselves and their abilities, are the ones most likely to succeed.

The inference of this logical thinking is by providing conditions in a school whereby learners improve their self-esteem, success may then be assured which will lead to more success.

The strategies which Friedland (1992:99-100) recommends to promote self-esteem are:

- (i) cooperative learning,
- (ii) outcomes-based instruction with each learner receiving the necessary time and support to achieve outcomes, and
- (iii) confluent education.

Friedland (*ibid*) defines confluent education as education where cognitive and affective components of a subject are intertwined. This in my opinion is one important characteristic which curriculum developers must attend to. Adding to the combination of cognitive and affective factors is the need to fuse a number of traditionally separate subjects into an integrated curriculum termed the thematic approach. I will now seize upon this opportunity to discuss some of the experiences which educators have had concerning the design of an integrated curriculum.

1.4.2.1. Curriculum integration

Artis (1994:28) is of the opinion that a school restructuring with an OBE system will require a tremendous amount of integration. The Kansas State Board of Education (1993:5) defines an integrated curriculum as one which unites all curricula through defined outcomes in order to meet the specific needs of all learners. The integrated curriculum transcends the entire schooling process in that it integrates all levels of outcomes and may include outcomes from a variety of programmes in courses and for grade levels.

O'Neil (1994:9) commentates upon Wiggins's observations (nd) that OBE proponents find it difficult to weave academic content into an outcomes framework in an effort to develop a less fragmentary course. The reason for the difficulty explains Anderson (1992:868) is because Science has a unique nature in terms of the Science concepts themselves and the modes of inquiry that produce them.

I agree strongly that course integration is very taxing and at the start of my fieldwork I agonised over the best way to achieve it. This is one reason why so much criticism has been leveled at OBE. Le Haye (1994:28), for example, accuses OBE of being a chameleon by nature, taking on different names and meanings in almost every case. The explanations for this is OBE is not a "program" but a way of designing, delivering and documenting instruction in terms of its intended goals and outcomes, as quoted in Spady (1988:5). This means that the vision of OBE can be interpreted in different ways when schools design their own programmes. More will be said about my approach in later chapters of this thesis, but presently I will consider the "design down" curriculum development process referred to above by the Kansas State Board of Education. This is an integral planning phase which must be punctiliously observed by any curriculum team. Thereafter, I will briefly consider,

from a teacher's perspective, two case studies reporting educators' experiences with curriculum integration. One, considers teachers' competency inside and outside of their teaching specialities while the other, a process approach applied in a Science curriculum.

1.4.2.2. The design-down process

It is important for schools to realise their responsibility with respect to the National Education Department. Through a consultative process, involving teacher unions, NGOs, tertiary level representations and input from industrialists and foreign consultants, the National Education Department formulated a series of outcomes. These are recorded in the government Gazette, 6th June, 1997 No 18051:139-173.

The outcomes are divided into three categories. The critical cross-field outcomes, the learning area outcomes and the specific outcomes. These outcomes are a *fait accompli* and represent what each learner is to perform or demonstrate after a programme has run its course. This is what the OBE-literature refers to as the exit outcomes. The Kansas State Board of Education (1993:8) defines exit outcomes as those formulated as integrated learning experiences which are the foundation for the total curriculum. The Board continues that from exit outcomes emerge programme, course/grade level, unit and lesson outcomes.

What becomes crucial for schools is to decide on outcomes at the course/grade level with further refinement at the unit and lesson levels by teachers. Particularly challenging in my view will be the need for new teaching methodologies and subject integration. We will now consider these important facets as they influence the teacher directly.

1.4.2.3. Participatory methodologies

As explained earlier, the outcomes-based education envisaged requires what Kgame (1997:8) described as participatory methodologies. Lakin & Wellington (1994:187) in referring to teaching of the nature of science admitted that few teachers are at home with such strategies as discussions, small group work, reading for learning, role-play or drama. They generally feel intimidated by such strategies because they cannot implement them effectively. This was precisely my own teaching experience when engaging in fieldwork.

Take the example of small group work in Science classes. Generally, two to six learners are assigned to perform an experiment. To function effectively Watts & Bentley (1992:62) advise that three characteristics of the group must be in evidence, namely:

- (i) a notion of membership and appreciation of its consequences,
- (ii) delineated roles of members, and
- (iii) shared norms.

It has been my experience that science teachers use group work experiments mainly to illustrate concepts and gather “objective” data as Hodson (1990:35) suggests. Teachers generally, do not explicitly stress the need for groups to allocate group-roles to its members prior to the experiment. More significantly, when the session is complete, the teacher does not generally allow learners to discuss and debate the evidence among themselves. There is simply not enough time for such long-winded activities. Worse still, the teachers ubiquitously assign group work to overcome the problem of equipment shortages. Better to have large groups working with a few items of apparatus than no experiments at all. After the session, groups are quickly dissolved and teachers set about explaining the concept which the experiment should have illustrated. Vygotsky’s theory judges this to be a fundamentally unsound practice.

Alexopoulou & Driver (1996:1099) refer to Vygotsky’s theory which stresses the role of language and discourse in shaping meaning. When group work is in progress the joint actions and communication of learners assist in construction of knowledge and meaning. To achieve this the teacher’s emphasis needs to go beyond illustrating concepts to teaching learners to work collaboratively. I will now consider integration in the curriculum. I will presently consider examples of where integration have been attempted in the curriculum.

1.4.2.4. Example of teachers’ experiences with integration in the curriculum

The sort of integration I have considered involves first, the integration of different Science subjects and second, the integration of a process approach into a Science course.

1.4.2.4.1. Case study I

The following explanation is my own summary of the key points revealed in a study by Sanders *et al* (1993:723-736). It considers research surrounding three experienced teachers who taught classes both inside and outside of their areas of certification. Their areas of

specialisation were Chemistry, Biology, Earth Science, and Mathematics. The unfamiliar areas were Astronomy, Physical Science and Photography. The article considered how effective and comfortable teachers were in and out of their area of certification with respect to their preparation, interaction with learners and later reflections after the lessons.

Teachers in an area of specialisation had a sound knowledge of the content of their subjects. They relied on notes prepared years before. Consequently, they were able to sequence concepts appropriately and manage their classes skillfully. In these classes, there was less teacher-input and more learner-centred activities. These teachers were more adept at facilitating risky activities such as discussions wherein learners were at liberty to ask difficult questions demanding a keen insight on the part of the teacher. The teachers could change the flow of the class readily and adapted to differences in student ability. They were able to accomplish this with consummate ease because they had such a diverse background in their subject areas to draw upon.

By contrast, these teachers in an area outside of their specialisations struggled more with their preparation. They lacked materials and tended to write more in the form of notes and had difficulty sequencing concepts. During classroom interactions, teachers tended to lecture more, steering clear of learner-centred activities. Occasionally, there were classroom management problems aggravated by difficulties with explanations. The teachers and their students often became confused and flustered which upset the timing of their lessons.

In reflecting upon their lessons in retrospect, teachers outside of their area of certification thought more about their teaching. They tried to think what needed to be clarified and improved and were uncertain about the effectiveness of their teaching in terms of student understanding. By comparison, teachers in their areas of certification, reflected more on their students and their understanding and participation. This was the case because they were confident in themselves that the learners had followed their content presentations.

1.4.2.4.2. Case study II

Instead of considering a traditional teacher's efficacy in and out of certified subject areas as was the case in the Sanders *et al* (1993) research, Gaskins & Guthrie (1994:1039-1056) describe a process approach to the science curriculum. The project aimed at integrating the

teaching of Science, reading and writing processes in a conceptually based, constructivist curriculum for early high school pupils who read below grade level.

The team who designed and implemented the curriculum consisted of a school principal, university researcher, research assistant, and two science teachers and their supervisors. Gaskins & Guthrie (1994:1053) concede that this task was formidable. One supervisor confessed that, “programme development is the most painful thing I’ve ever been through in my life, including childbirth ... and I think it’s especially hard for somebody who’s never been through it before because they don’t know for a fact that there is a pot at the end of the rainbow”.

From a teacher’s perspective the real challenge was not so much in assisting learners towards a better understanding of key concepts, but in teaching learners how to do, think, read and write about Science. What was involved was planning, arranging and then facilitating a classroom experience wherein learners could really do and learn Science. This meant working with assiduity to create circumstances wherein learners would observe and interact with real-world objects and events, make predictions about how they work and read to research what others have learned about them in constructing and writing explanations, as quoted in Gaskins & Guthrie (1994:1040).

This is the essence of the process approach which leads learners to detect patterns and test predictions through reflective observation. Learners were then encouraged by their teachers to make connections between the evidence of their observations and what was recorded in reference books through the medium of collaborative discussions and negotiated explanations. The whole integrated process rested on students’ ability to manipulate and critique what they read and wrote in an attempt to solve real-life problems.

Teachers were initially dubious as to whether or not learners were capable of higher-order thinking. In connection with pre-assessment Gaskins & Guthrie (1994:1051) quote one teacher: “When we did that pretest thing ... I, in my own head, predicted disastrous results. I kinda, said, no way, these kids are going to die. This is too hard for them.” But contrary to those initial prejudices concerning pre-assessment, expectations of students’ capabilities and potentials changed, although student accomplishment was not always remarkable.

1.4.3 Assumption III

Spady *et al*'s (1994:30) third assumption is: Schools control the conditions that directly affect successful school learning."

In this section I intend to acknowledge the influence of "tests" on the curriculum and will discuss the type of testing which OBE proponents advocate. Since learners are directly affected by the assessment process, I deem it necessary to consider learner and parental attitudes towards OBE in general and more specifically towards assessment. Finally, I plan to explore more closely what "controlling the conditions of success" means for schools in terms of accountability.

1.4.3.1. The influence of the test

In OBE, the emphasis lies not so much on a learner's ability to recall information, but depends more on what he or she can do in practice with that knowledge or skill. This is particularly important for future employees or universities who will attach high stakes to these demonstrations of competence. Consider an apposite quote from the work of Madaus (1979) recorded by Darling-Hammond (1990):

Evidence from many studies demonstrates that, when such high stakes are attached to scores, tests can be expected to exert a strong influence on "what is taught, how it is taught, what pupils study, how they study, and what they learn."

I will now explore the form of assessment which is touted to exert such an influence.

1.4.3.2. A holistic form of assessment

Lubisi *et al* (1997a:123) explain that South Africa's Curriculum Framework has opted for a holistic form of outcomes-based assessment. Lubisi *et al* (1997a:131) define the term "holism" to imply that things are connected. So what is connected?

At the level of assessment a holistic understanding will only judge a learner to be competent if she is able to integrate the required knowledge, skills and values in different contexts. At the classroom level "holism" means continually combining assessment, teaching and learning instead of the fragmentary traditional approach, characteristic of which is a test tagged on at the end of a unit, as quoted in du Toit *et al* (1996:30).

Watts & Bentley (1992:170) reporting on the work of West and Wilson (1990) elaborate upon the implications of holistic assessment for learners. At the start of a course or unit, learners would be introduced to the assessment criteria – a list of what is to be achieved and level of competency. As the course or unit progresses, learners would be afforded the opportunity to test their progress at frequent intervals – a process termed self assessment. Adequate provision would be made for learners to assess each other's work and to suggest suitable changes to assessment tasks and criteria. Up to this stage, the form of assessment may be described as developmental, diagnostic or formative. In the final stages of the course or unit, summative assessment unfolds after negotiation with peers and teachers and the results of all assessments would be incorporated in a Record of Achievement called profiles.

1.4.3.3. The instruments of holistic assessment

Since OBE practice is characterised by frequent monitoring of a learner's progress and cognizance is continually paid to individual learning styles, Grover (1994:175) remarks that a variety of assessment procedures are employed. The purpose being to evaluate learning and diagnose the need for additional instruction. This is far removed from the function of traditional assessment which is to test, label and categorise learners.

Although an exhaustive list of assessment strategies exist I will describe four which impacted upon my research, namely criterion-referenced tests, portfolios, and performance assessment defined by Grover's synopsis (1994:175-176). Thereafter follows the most challenging form to implement, namely, authentic performance assessment.

1.4.3.3.1. Criterion-referenced tests

These tests use questions based on what the student was taught to measure how much the student learned from that instruction. Such tests may use multiple choice or essay questions, or a combination of both.

1.4.3.3.2. Portfolios

A portfolio is a file of student work centered on a particular topic or content area. It is now used as an assessment technique where specified contents of the portfolios are reviewed according to established criteria to determine the level of student performance and progress.

1.4.3.3.3. Performance assessment

This form of assessment requires students to perform a test rather than simply answer questions. It may call for writing or solving math or science problems or completing a science experiment. It is judged against established criteria.

1.4.3.3.4. Authentic performance assessment

I will now continue with a brief discussion on authentic performance assessment which is described by Bergen (1993-94:99). She refers the reader to Spady's (1992) definition of an "outcome" which informs about what students have learned and can demonstrate in performance. If this is the case, Bergen argues that "authentic" performance assessment is that which evaluates what children can do in actual or simulated applied situations.

The reason why authentic performance assessment has been introduced in OBE systems is explained by Manges *et al* (1995-96:10). These authors draw attention to the growing demand of employers for secondary and post secondary schools to produce graduates capable of performing in the "real world" workplace. To accomplish this, communication skills, problem-solving skills and critical thinking skills are a prerequisite. Pearce *et al* (1992:21) expands upon this by quoting Resnick (1987) and provides a more amplified list of features inherent in higher-order thinking. These include: non algorithmic, complex, multiple solutions, multiple criteria, uncertainty, self-regulation, imposing meaning, and effortful. Manges *et al* (1995-96:11) are correct in their commentary that these high levels of thinking are a definite move away from outcomes emphasizing *recall* to those emphasizing *resourcefulness*. To be resourceful, learners are compelled to focus on analysis, synthesis and evaluation skills.

Well, if higher order thinking skills are the target of learning then exactly what are the learners feelings towards outcomes-based education? I will now explore this further.

1.4.3.4. Learner attitudes towards OBE

Keefe *et al* (1992:28) speak from experience derived from their work in the Essential Schools in the United States in the 1980s-90s. To initiate OBE programmes it was found that principals and teachers encountered much opposition and even hostility from learners. This

occurred, in their opinion, because more was expected of the learners who were then required to work harder. Although this situation prevailed initially, the environment improved considerably over the years as the students began to acclimatise to the new requirements of higher order thinking. The students' esteem and morale became elevated by the respect shown by teachers who actually expected them to work, to arrive at independently determined answers and take responsibility for their learning. Teachers in these Essential Schools have found the results of graduating seniors extremely encouraging.

Be this as it may, in my opinion the most formidable barrier obstructing any change from a traditional form of assessment to one demanding higher-order thinking skills is the existing mind-set of the learner. Webster (1994:30), a dedicated post-secondary teacher, in making the transition from traditional methods found that her students only wanted to learn enough to pass. The grades they had obtained merely reflected what they had crammed into their heads the night before. Her students never accepted responsibility and consequently never utilised higher-order thinking skills in applying their knowledge in "real-life" circumstances. Suffice it to say, Webster changed these conditions, but not without toil and sacrifice.

This is understandable because Marzano (1994:47) alerts us to the fact that learners generally do not perform well on performance assessment tasks. Teachers complain that they are difficult to compile and since so few are available, they tend to supplement performance assessment with traditional tests. This is dangerous in my opinion because it sends conflicting messages to students who then struggle to prioritise their learning.

Perhaps more of a misunderstanding than a mind-set problem which learners have concerning OBE is the notion of expanded opportunity explained by Spady (1988:7). Guskey (1993:35), commenting upon traditional schooling, notes that learners believe they have a fixed amount of time to spend preparing for tests. Once completed and the marks are recorded then no second chances are available. This is bound to cause confusion in the early stages of OBE implementation because learners are no longer constrained by time limitations. They can try and try again. What is important is successful mastery.

I will now explore another potential threat to the implementation of OBE – the reluctance of learners to read about Science.

1.4.3.4.1. Learners' reluctance to read about Science

Cohen (1993:792) argues that a focus of OBE will be on conducting a search for information by the learner rather than being instructed what to learn. This implies that the learners will need to be competent readers if acquisition of pertinent knowledge is to be successful. However, Lemke (1990:22) observed that students are not taught to use language in speaking, arguing, analysing and writing Science. A reason for this omission is to be found in the research of Lunzer & Gardner (1981) as quoted in Carré (1981:80). These researchers quoted Science teachers who posited that reading was not "a very reliable way to introduce a topic, nor was it an especially effective way of acquiring information for most children of school going age".

This neglect in children's education has created a certain perception of Science education in the mind of the learner. The consequences are expanded upon by Lakin & Wellington (1994:187) who refer to a science teacher's interpretation of a child's expectations:

They don't expect reading and discussion or drama and role-play – they do expect bunsen burners and practical work. They don't want to learn that Science is not a set of facts ... They see little place for their own interpretations or theories but want to know what should happen in a particular investigation and what this proves.

Therefore, an OBE curriculum will be strongly opposed by this negative perception on the part of Science learners. To remedy the situation, Ogborn (1991:44) offers some sound advice. She suggests that to assist pupils towards becoming effective communicators they should be given well-written, accessible materials in science books, magazines and newspapers.

In my experience of Science teaching I have found few accessible and interesting articles. They tend to discourage even the most ardent of enthusiasts through excessive use of technical terminology. For this reason, most articles will require extensive editing and "toning down" to be consistent with the reading ability ranges of learners. This will demand many hours of painstaking work on the part of Science educators, but is of inestimable benefit if Lemke's assertions are correct in that learners need to be taught to talk Science. To do this – prioritise reading in the teaching repertoire.

According to Boschee & Baron (1996:576), since parents are significant stakeholders in their children's learning, I will briefly consider what some parents have to say about OBE.

1.4.3.4.2. Parental concerns about OBE

Rogers' & Dana's (1995:16) research reveals that some parents are apprehensive that no conclusive proof exists that OBE works. Parents have objected strongly to any suggestion of involving their children as "guinea pigs" in an educational experiment.

Rogers & Dana (*ibid*) defend OBE emphasizing that it is not a single curriculum or a single set of instructional strategies. Therefore, it is the parents' responsibility to examine the OBE "package" which is implemented in their local education community. This may be difficult, however, because OBE is laced with technical jargon opines Schwarz (1994:87). For example, she asks what the following will mean to any concerned party: "Outcomes are high quality, culminating demonstrations of significant learning in context"? Admittedly the language of OBE is difficult to decipher and is bound to cause more than its fair share of confusion. I had some unfortunate experiences with jargon during the course of my fieldwork which I will explain in due season.

Finally, I will analyse the importance of autonomy, control and accountability as they all influence assessment.

1.4.3.5. Autonomy, control and accountability

In an OBE-system government schools and the National Education Department are bound by a relationship of autonomy and control as mentioned earlier. To refresh the reader's memory, Boschee & Baron (1996:576) explain that the State decides on the targets for student achievement (i.e. the outcomes). This is the control facet of the relationship. Schools are to provide suitable programmes so that learners may demonstrate these outcomes. It is the responsibility of the local community to develop a plan to achieve successful results. This is the autonomy facet of the relationship. This leads onto the next important consideration – accountability.

Keefe *et al* (1992:35) explain the concept. Accountability means gathering more precise information about student achievement on a periodic basis:

- ♦ through indicators that can be compared over time across classrooms, schools and districts and make the information more accessible to the public, and
- ♦ allocating more dramatic (positive and negative) consequences for performance to students, teachers, schools and districts.

Keefe *et al* (1992:35) argue on the one hand that accountability is positive in that it provides taxpayers, parents and students with quality documented evidence of a school's service. Traditionally schools have not done this because test scores belie what students have learned at school.

On the downside, Keefe *et al (ibid)* acknowledge that there is little consensus in American schools on what standards should be used to evaluate student performance. Hence, how can government schools be compared? More significantly, in attempting to establish a fair accountability system, there may be the need to establish standardized achievement tests to the neglect of authentic achievements.

I have two problems with accountability. In the first instance, accountability, according to Monk (1992), quoted in Furman (1994:429), assumes a casual link between educational practices and outcomes. My criticism supported by Porter (1993), quoted in Furman (1994:429), is that no concern is apportioned to possible defects in the system, such as high pupil to teacher ratios or the poor socio-economic circumstances of some learners. These interfering variables must differ widely between schools, but have a very pronounced effect in determining whether or not achievement is possible.

My second concern is mirrored by Worthen (1993), also quoted in Furman (1994:430), who questions whether assessment bias can be controlled.

Some authors such as Woolnough & Toh (1990:128-129) advocate, in the context of assessment of practical course work, that teachers should be given general criteria and then be left to make their own professional judgements. Black (1990:25) takes an even more extreme line contending that a teacher who records a pupil's performance over time and in several contexts, and can discuss the idiosyncratic answers of learners can compile a more reliable record than any external test. I say this is true until animosity or favouritism exists

between learner and teacher which will more than likely cloud judgement to the detriment of the learner.

In final analysis, the moment links are made between practice and outcomes while ignoring interfering variables and bias, problems will arise and accountability will prove contentious.

Chapter 2 : Research Methodology

2.1 Introduction

Since my research questions require a deep and thorough understanding of social issues within the complex environment of schools, I have conducted my fieldwork from the vantage point of the interpretivist paradigm. In light of the fact that school situations are often unique, I have described events in relation to OBE in terms of two separate case studies. Quite characteristic of these studies are qualitative research methodologies of which the most important are participant observations and in-depth interviews. To complement the data gathered, I have also utilised the instruments of journals, written artefacts of learners and their teachers and photographic evidence. In order to triangulate my data effectively and confirm its internal validity, I have also resorted to the use of questionnaires. The inclusion of questionnaires, generally associated with positivistic methodologies because of its quantifiable attributes, is justified on the basis of Reichardt's & Cook's (1979) advice that instruments should be used as eclectically as possible, as quoted by Vulliamy (1990:9).

It is my purpose in this chapter to explain to the reader why it was necessary to select an interpretivist approach and how I used the various research instruments in the compilation of the case studies. Quintessential to my explanation are the circumstances within which my fieldwork was grounded and how they influenced my decisions. I begin with a justification for an interpretivist approach to the project.

2.2. Justification for the interpretivist approach

Jackson (1995:10) elaborated upon the interpretive assumptions about science and human behaviour. In his explanation, Jackson (*ibid*) reveals that the interpretive approach examines how people make sense of their lives and how they define their situations. At the start of an interview with one of the science teachers at Mtunzini Secondary School, I was asked to justify the purpose of the interview. This was my reply:

The purpose of the interview is to find out from a practising science teacher where the systemic problems may lie if an outcomes-based education type curriculum were to be introduced into this school. I need to establish your impressions from what you have read about it, and from your own experience as you go from day to day in your teaching practice. It would be very difficult for me, from a visitor's perspective, to see some of the problems; some of the issues which may arise because I don't have the background knowledge; a

knowledge of the culture of the school ... and ... um ... which I should imagine is very much in the forefront of your own mind.

Essentially I was trying to establish how people in their natural circumstances of the classroom made sense of the possible implementation of OBE into their existing school systems. In the opinion of the role players, I was trying to establish where the aspects of continuity and the aspects of departure existed should an OBE system be introduced in a formerly traditional teaching environment. True, I had a fairly shrewd idea from my continuous referral to the literature, but I needed to place the issues within the authentic contexts of two South African schools. I needed to capture their opinions on tape or in questionnaires or journals while recording careful observations in my field notes. The way to accomplish such a task was to operate within an interpretivist framework.

2.3. Reasons for framing my research questions within the boundaries of a case study

Abagi (1995:13) contends that society and its institutions comprise an enormous and complex world. If this is the case then each school has its own unique characteristics, which may differ tremendously from one to the next. Hence, Abagi (*ibid*) claims that a social scientist's challenge is to understand and explain such issues. It is for this reason that the two schools, namely, St Sebastian's College and Mtunzini Secondary School formed two separate case studies.

St Sebastian's, after a superficial glance, is completely different to Mtunzini. The former is entirely administered by White South Africans, the latter by Black South Africans. The cultural differences between the two racial groups must provide for an immediate difference in worldview and is a major contributing factor in the creation of different learning environments. Furthermore, St Sebastian's is reputed to be an elite school in South Africa, sporting some of the finest educational resources in the world. Mtunzini, on the other hand, can be classified as a deprived environment in comparison. These circumstances were brought about through the legacy of Apartheid. Consequently, whereas the issue of sport and cultural activities play vital roles and occupy a considerable amount of time in the lives of St Sebastian's school boys, those issues are of little significance at Mtunzini. Quite to the contrary, Mtunzini is beset by more 'bread and butter' issues such as teacher retrenchments, crowded classrooms and lack of resources and support from an often apathetic provincial education department.

Being mindful of these considerations, I feel justified in separating my research into two separate case studies, described in qualitative terms. However, if there is an acknowledgement that such extreme differences exist, then it raises the perennial spectre of justifying such case study research in terms of external validity. Anderson (1990:164) defines the term as whether or not the findings of one case can be generalised to other situations. More specifically, can the conclusions drawn from the St Sebastian's and Mtunzini case studies be extended to other schools across the country as they grapple with the implementation of OBE? It is this pertinent issue which deserves more attention.

2.3.1. Justifying my case study research in terms of external validity

The reader will recollect my statement that superficially, St Sebastian's and Mtunzini were completely different. I based my argument upon the separate world views of the respective administrations and the vast resources of the one school versus the limited resources of the other school. However, upon deeper analysis, St Sebastian's and Mtunzini are very similar in terms of core systemic considerations.

In the literature review, I quoted Spady who argued that traditional schools are controlled by two factors, namely, the calendar and custody. Each year, schools are obliged by law to be operational for a certain number of days. Each day, subjects are offered within the confines of a rigid time-table and learners are only eligible to proceed to more advanced levels after their year of custody has expired. This regimented approach which has held sway since the Industrial Revolution has become so intimately intertwined within the fabric of schools as systems that it is hardly ever questioned. In addition to Spady's factors, I do not deem it inappropriate to mention a further characteristic common to all South African schools, namely, the orientation towards the matric exam system. All schools are subject to the constraints of a broad syllabus and it is the mission of these institutions to prepare pupils as well as possible within a limited time frame.

If Spady's observations and my own refinements are correct then schools throughout South Africa all adhere to the same common denominator. Therefore, the systemic problems of introducing OBE into a time-based structure are widely applicable to most other schools nationwide. Science teachers will be waylaid by the same problems and difficulties which I experienced. For this reason, I can assert with some conviction that the case studies which I have presented are externally valid.

2.3.2. The issue of internal validity

Robson (1993:403) refers to the neutrality issue in research which is raised by Lincoln & Guba (1985). The question posed is: "How can we be sure that the findings are determined by the respondents and the situation and context, and not by the biases, motivations, interests or perspectives of the enquirer?"

This is not an easy question to come to terms with. One of my main research instruments was the in-depth interview and Bell (1993:95) refers to the problem of bias in interviews discussed by Selltitz, Jahoda, Deutsch & Cook (1962). These authors are critical of the interview as a research instrument in that interviewers may "lead" the respondent and if the same question is asked by two different people, with different emphases and intonation, it may yield different responses. Atkinson & Hammersley (1994:254) confirm Selltitz *et al*'s opinion by acknowledging that there is no perfectly transparent or neutral way to represent the natural or social world. So, what is to be done about it?

Anderson *et al* (1994:111) provide a viable solution. They suggest that qualitative researchers address subjectivity by incorporating and openly discussing it. This I attempted to do. The reader will recall that in the opening paragraphs of chapter 1, I admitted my biases by assuming that current traditional schools have neither an appropriate system nor the will to support an OBE curriculum. In chapter 3, I compared Andy Christianson's epistemology to his classroom practice and noted the inconsistency. I may be criticised for the fact that I had based my conclusions upon one lesson, but then admitted that the following series of periods which And may have offered were more in keeping with his philosophy. In chapter 4, I had many apprehensions and concerns when initiating my fieldwork at Mtunzini. I discussed these openly making no attempt to conceal what may have influenced my research.

Another means to cope with internal validity problems is presented by Stake (1994:241) who quotes Flick's (1992) method of triangulation. This method is generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation. Fontana & Frey (1994:373) speak of one method of triangulating where a researcher uses several methods in different combinations. These authors provide the example of Morgan (1988) who suggests complementing survey research with interviews and participant observations. This multimethod approach I used continuously to verify the authenticity of my observations. Take for example the issue of learners at Mtunzini being

unoccupied during school time because of teacher absenteeism which I explained in chapter 4. Large crowds of learners were seen wasting their time because they were not supervised. I was not content to merely photograph learners lazily basking in the sunshine. I interviewed teachers, administrators and learners to gather diversified opinions. To complement this data, I employed the use of questionnaires which required of learners an explanation as to how they utilised their time.

In summary, the way to cope with the issue of validity was to admit to the problematic nature of it and then attempt to verify the authenticity of observations with a wide selection of research instruments.

2.3.3. The literary style of the case study

Cohen & Manion (1994:123) express the view that case studies typically present research data in a more publicly accessible form than other kinds of research reports. The language and the form of presentation is less esoteric and less dependent on specialized interpretation than conventional research reports. For this reason the case study serves multiple audiences. It does not demand extensive knowledge of implicit assumptions, so making the research process more accessible.

In accordance with Cohen's & Manion's observation, I have presented the case studies of the two schools in a far less formal and academic form than would characterise other research reports. It is my hope that school communities throughout South Africa will be able to comprehend the import of what is being described and so implement OBE in their circumstances more successfully than I managed to accomplish.

2.4. Research instruments: technical aspects and experiences surrounding their employment

2.4.1. The questionnaire

Throughout my fieldwork I compiled and administered four questionnaires. At St Sebastian's, one questionnaire was completed by four members of the Science department and the other was completed by the learners of Grade 8Z. A similar pattern was followed at Mtunzini with a member of the Science department and an administrator completing the teacher questionnaire while the learner questionnaire was filled in by the learners of Grade 8G.

2.4.1.1. The purpose of the questionnaires

For the purpose of this discussion refer to appendix A where questionnaires which I designed are located.

According to Oppenheim (1992:100) the questionnaire's function lies in measurement. Beginning with the learners at St Sebastian's, I wished to determine how their time was occupied each week. I pursued this course of action because I was constructing a case that would explain that learners were too preoccupied with sport and cultural activities to dedicate time to their reading. To accomplish this successfully I devised questions which inquired of learners which sports and extramural activities they participated in and the corresponding number of hours that they were engaged in such an enterprise. Interspersed in the questionnaire were questions regarding the books that the learners read and the number of hours per week which they spent reading this literature. Once analysed I presented the data in the form of bar graphs which was most informative, revealing in graphic detail, the over-emphasis which St Sebastian's places upon sport and cultural activities.

Concerning the questionnaire presented to learners at Mtunzini, I was particularly concerned about how influential socio-economic factors were on a child's schooling. In question (3), I asked the learners to tick the appropriate box pertaining to the distance they travelled from school to home. Question (4) inquired as to the means of transport. After analysis, the average learner is faced with a 4-5 kilometre walk each day just to reach the school. I used this evidence to explain why I thought the school was harsh in excluding learners who arrived late for lessons in the morning.

The two examples mentioned explain how I used Oppenheim's idea that questionnaires are used for measurement.

I was less concerned, however, with the measurements when considering the questionnaires for adults. In their case, I wished to gather data concerning how suitable OBE was for their particular circumstances. When analysing the data, I became intrigued with the responses to questions towards the end of which required open answers and more thoughtful input than marking a number on a Lickert scale of 1 to 9. In effect, I was asking teachers to make

predictions should an OBE curriculum be implemented. I was trying to ascertain their attitude towards such a system.

Concerning these questions, Mr Robinson (a science teacher at St Sebastian's) was puzzled by the term 'formative assessment'. This was valuable data, outside of the questionnaire, which revealed that even experienced teachers are not familiar with the jargon and had probably not contemplated the full import as to what changes may result if OBE were to be implemented. Gavin Cook (a colleague of Mr Robinson) was equally baffled by the questions at the end of the questionnaire which involved a transformational OBE system. He complained bitterly that my questions were too vague and so never responded to the latter part of the questionnaire. For example, question 7(c) inquired as to, "How accurate are St Sebastian's exam/test results for measuring a person's academic prowess.

I suppose Jackson's (1995:373) point is well taken. He advises researchers to minimize the number of opinion-seeking, open-ended questions because many respondents feel that it is an imposition and too time consuming and so leave the spaces blank. Cohen & Manion (1994:94) take an even more extreme view suggesting that open-ended questions be avoided completely since the answers of respondents cannot be probed to determine the full meaning of their answer.

2.4.1.2. The design of the questionnaires

2.4.1.2.1. The learners' questionnaires

Since the learners at St Sebastian's and Mtunzini were approximately 13 years old, I began their questionnaires with nominal questions. This is the simplest type of question requiring the identification of a fixed category, for example: "What sport do you play?" or "How far is your home from school?"

To make the questionnaires more comprehensive I included open-ended questions for purposes of clarification. At the time of compilation, I did not realise that most learners in the respective schools were illiterate or verbally inexpressive at best. Therefore, valuable data was omitted. This is a problem referred to by Oppenheim (1992:107) where he advises one to be more cautious in devising questionnaires for children.

In addition to the nominal questions, I also included interval scale questions. It was challenging to select the attitude categories since the questions related to different aspects of my teaching and no single set of attitude categories was applicable. Relating to the scale questions, I used an agreement scale or Lickert scale. The scale reflects upon the intensity of an attitude or an opinion which is sought. (Research Methods notes, Rhodes University, 1996:7).

The final type of questions included were of the rank-ordering variety. Jackson (1995:374) explains that when presented with these questions, respondents are asked to indicate an ordering of response items, usually from most to least preferred. In the case of Mtunzini and St Sebastian's I asked learners to rank what they considered to be their priority list of activities at school. In both cases, learners ranked the scoring of 100% on a science test as one of the most important items.

2.4.1.2.2. The teachers' questionnaires

The formats used for the adult questionnaires were essentially of four kinds. The first was ordinal questions listing responses on a continuum (Research Method notes, Rhodes University, 1996:3). Associated with this kind of questioning were what Jackson (1995:386) would refer to as "reliability checks" or repeated questions. I noticed on one of the questionnaires that a respondent marked '5' when asked to gauge support from colleagues in the Science department. His estimate rose to '7' when asked to gauge collegiate support should OBE be introduced. His interpretation and reasoning for the difference are difficult to determine with such limited information.

The second type of question was that of rank-ordering. I asked teachers to estimate what was most important to learners at the school. In most cases, at Mtunzini and St Sebastian's, scoring 100% on a science test was of top priority.

The third type which has already been discussed is that of the open-question where unbridled opinions were sought. The fourth type, although of restricted useage, was of the nominal type. One particular example caused a great deal of confusion in my mind. The nominal question asked teachers at St Sebastian's to judge whether their school was product or process oriented. Two of the four science teachers believed that the school was product-oriented. One believed that the school was process-oriented, while another occupied middle ground

adding a response to the effect that the school was 60% product and 40% process. This inconsistency I did not expect because they are all part of one department and yet seem to be following different policies in their classrooms.

2.4.1.3. My experience in administering the questionnaires

2.4.1.3.1. The learners' questionnaires

The most disappointing submissions were received from Mtunzini Secondary School. I left the administering of the questionnaire to their normal class teacher because I had urgent commitments elsewhere. Unfortunately, the learners did not complete the questionnaires in one class period and were asked to return them the following day. Learners misinterpreted the situation and thought the questionnaire was a class test and so there was evidence of learners sharing responses which reduced the credibility of the data.

In addition, learners were of poor literacy and not verbally expressive and this limited data capture to a minimum.

2.4.1.3.2. The teachers' questionnaires

Oppenheim (1992:102) referring to postal questionnaires identifies that it is characterised by a low response rate. I thought at the stage of issue that I would enjoy a high response rate because the teachers were responsible academics and I had direct contact with them. How sadly disillusioned I became. I pursued teachers for three months at the one school who continually delayed completion and in the case of the other school, respondents either lost their questionnaires or never bothered to make an attempt.

I do not believe such negligence can be attributed to lack of integrity, but rather to pressured commitments. Take the example of St Sebastian's. Teachers spend 80 hours per week engaging in activities associated with the school which leaves precious little time for the mundane requirements of questionnaire completion.

2.4.2. Interviews

Mishler (1986:ix) explains that the central question in social and behavioural sciences is to find out how individuals perceive, organize, give meaning to, and express their understanding of themselves, their experiences, and their worlds. For the purposes of exploring the possibilities of introducing OBE into traditional learning environments, no research

instrument proved to be more effective in probing people's perceptions and opinions than the interview.

Note that I use the word "interview". The reason is interviews, according to Fontana & Frey (1994:361), range along a continuum from structured, to semi-structured. When I began my fieldwork at St Sebastian's, I decided it was more prudent to prepare a fixed schedule of questions which I could pose to respondents. This was the advice of Dunsmuir & Williams (1991:95). In the initial stages I found that recourse to a schedule helped to maintain the flow when I exhausted fresh ideas. However, as I became more familiar with the interview process and read more broadly on the subject, so my interview approach progressed more towards the "elite" interview described by Anderson (1990:223). The emphasis in these situations became probing; probing the views of a single individual. In my case the individuals were either school administrators, teachers or the learners whom I taught. In their own way, they were all unique and it became my approach to continually allow the respondent's answers to evolve the conversations as Paget recommended, as quoted in Mishler (1986:97). Consider the following exchange between myself and Mrs Khumalo, a Science teacher at Mtunzini.

Interviewer: Now, you have mentioned that their English is poor and so forth. Now, most of the project materials which they are going to collect will be in English.

Mrs Khumalo: In English and they need to read.

Interviewer: OK, now ... we get to the key issue of reading and accessing of information. How would you help kids to read more?

From this section of the interview, the reader will observe that it was myself who linked project materials and the fact that they were written in English. I never referred to the learner being able to read. This was Mrs Khumalo's suggestion. Once she had raised the issue, I pursued the matter. The point I am trying to make is the evolutionary nature of this in-depth type of interview.

The second characteristic of my interviewing style was to paraphrase important ideas after a person's commentary. Anderson (1990:230) indicated that this practice crystallises what has been said and increased validity because the respondent will either accept the abridged version or clarify points. The following is an example of the approach used in this regard and concerns the exchange I had with an interviewee who was relating how tests are conducted.

Interviewer: Now, how would they give you a test and how would you learn for that test so that you could pass and do well? ... which I am sure you would want to do?

Respondent: Well, mevrou is a good teacher and she teaches us, Sir, the work so we understand it and then she'll tell us there is a test and if you want to learn it, say, read the first chapter of the book or sometimes she will give us a worksheet and she'll say that this is ... and so we'll make it ... I'll remember it.

Interviewer: So it's a question of taking a textbook or worksheet and learning what it said?

Respondent: Yes.

Aside from the basics of probing and paraphrasing, I also tried to adhere closely to Stake's (1995:65) advice of listening closely to what was being said and not settling for a simple 'yes' or 'no', but coaxing the respondent towards a description of an episode, a linkage or an explanation.

The important issue of reliability and validity was raised earlier and Anderson (1990:228) opines that the greatest threat to consistency and authenticity lies in distortion brought about by verbal messages which are sent and received. Fontana & Frey (1994:371) speak not only of the verbal interaction, but also of nonverbal elements which may influence the course of an interview. For example, these authors quote Gordon (1980) who recommends that the interviewer be cognizant of kinesic and paralinguistic communication. These finer nuances refer to the subtle body movements and variations in volume and pitch of the voice. In recognition of the importance of these external matters, I tried to adhere to Anderson's

(1990:226-227) recommendation of interviewing respondents on their home territory while facing the interviewee and dressing according to expectation. For example, I dressed formally when interviewing the deputy headmaster of Mtunzini, but dressed informally when interviewing grade 8Z learners of St Sebastian's on occasions of visiting their dormitories for interviews.

2.4.2.1. Practical problems experienced to arrange interviews

As I will explain in the St Sebastian's case study, time is of a premium and learners are not easily accosted for an interview after school. In concession to their pressured programmes I had to arrange with the deputy principal, weeks in advance, to secure a suitable time and venue. Upon extensive negotiation, the deputy granted me permission to interview learners on six consecutive evenings in their dormitories. To meet my research commitments I complied, and, with quite some inconvenience, managed to interview learners between 7:30 pm and 9:30 pm on the evenings suggested.

The situation at Mtunzini was even more precarious as far as interviews were concerned. I can vividly recall that after gaining permission to interview learners, I was limited to one afternoon's interviewing. The learners, I knew from experience, were not that reliable, and even after much entreaty would simply not return for an interview after school. Not to be daunted by the impending examinations or the looming teacher strikes, I decided to bribe learners with 'coke and cake' to grant me an interview. Photographs 2.1 and 2.2 show learners enjoying their culinary delights before commencing with the highly prized interviews.

At the end of my research, I conducted interviews with 31 individuals. Some were more successful than others and strangely enough depended mostly upon the rapport between us. I felt that if the element of trust existed then respondents were more willing to converse. The point of Fontata & Frey (1994:374) is well taken. "Yet, to learn about people we must remember to treat them as people, and they will uncover their lives to us."

2.1



2.2

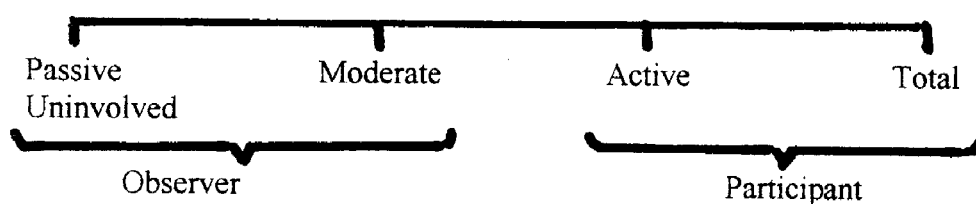


Learners enjoying 'Coke and Cake' before our interviews

2.4.3 Participant and non-participant observation

Anderson *et al* (1994:130-131) explain that a participant observer does not necessarily interact with participants, but because of its long history in anthropology a participant observer is one who is there, in the field, observing people in their natural surroundings. This situation occurs as opposed to reading other authors' accounts in the research literature.

With this in mind Anderson *et al (ibid)* explain that there exists a continuum of participant observations. These authors present the types of participant observations according to the following spectrum:



A continuum of participant observation

Figure 2.1

Considering this diagram, I classified my role in the classrooms of St Sebastian's and Mtunzini as a passive uninvolved observer, a moderate observer and an active participant. I operated in the first capacity when merely observing the lessons of teachers to establish the expectations which learners had of school. I operated as a moderate observer when I asked learners questions in another teacher's class. In contrast, I acted in the third capacity when trying to organize constructivist classes to determine the response of the learners. I will now consider the first and third categories in more detail.

2.4.3.1. Passive uninvolved observation

When acting in this vein, I tried to adhere to the advice of Dunsmuir & Williams (1991:74). These authors recommended that it is better to remain as inconspicuous as possible. For this reason, I attempted to blend into the background, sitting quietly with field notes, camera and tape recorder causing minimal disruption. The thinking here was not to enter into class discussions or activities which may influence the course of events and invalidate the data. I made extensive use of the photographic evidence, recorded transcripts and field notes when

observing teachers at the schools to develop contrasts and parallels. A good example of this is to be found in the St Sebastian's case study concerning the lesson and interview of Andy Christianson.

2.4.3.1.1 The field notes

What is of particular interest is the method I used to write my field notes. Bennaars (1995:124), incidentally, quotes Bogdan & Biklen (1979) who define field notes as "the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study."

To collect effective field notes in a passive uninvolved capacity, I first drew a diagram of the basic layout of the classroom and recorded the rough starting positions of learners in relation to the teacher. The diagram and field notes in appendix B provides the reader with an example.

The filed notes are dated and such particulars as the teacher, class and topic are all documented. Thereafter, the reader will notice that the diagram is annotated with comments referring to what the boys and teacher were doing in relation to the time. Note that the "Sink or Float" continuation began at 2:45pm. Every time a significant event would arise, I would simply record the details and the actual watch-time. Later I could calculate the number of minutes which passed in relation to the observed activities of the learners. In accordance with Anderson *et al's* (1994:134) stipulation, I always wrote up the notes as soon as possible. The field notes helped me to identify whether a transmissive approach was in evidence with learners receiving what the teachers taught or a more process-oriented approach which was learner centred.

2.4.3.2. Active participant observation

Anderson *et al* (1994:131) define an active participant as one who seeks to do what the participants in the research scene are doing to better understand the process. In my case, I assumed the role of classroom teacher and designed and facilitated a course more in keeping with OBE principles. During my classroom sessions I was too busily engaged in teaching and organising the class and could not compile detailed field notes of the events. However, I did make use of the tape recorder and after class transcribed the proceedings while

compiling notes in my journal. It is the issue of journals and physical artefacts of learners which deserve more attention.

2.4.4. Journals and physical artefacts

2.4.4.1 Journals

Anderson *et al* (1944:153) refer to journals as encouraging description, interpretation and reflection on the part of the teacher as well as the student.

As soon as significant events occurred in the course of my research, I recorded them as anecdotes in my journal. This was particularly important because the finer details of these portrayals would easily fade from memory. In the case study of St Sebastian's I related an anecdote concerning the research of Mr Robinson. Without the use of the journal there is no way I could have remembered the finer points of his narrative. Although journal keeping is tedious it, nonetheless, offered me some colourful descriptions when writing the case studies.

Unfortunately, the journals of the learners of St Sebastian's were poorly maintained while that of Mtunzini were non-existent. The reason for this is learners were so pressurised by their commitments or of such poor literacy that no journal entries were submitted on an on-going basis. At the end of my St Sebastian's fieldwork I had to bribe the learners with 10 extra marks to motivate learners to write a couple of paragraphs!

2.4.4.2. Planned artefacts

2.5. Anderson (1990:160) in referring to the six sources of data mentions the collection of physical artefacts of learners as an option. The artefacts which I collected and immediately photocopied were that of learner assignments, tests and practical write-ups. I did not allow this data to collect, but started the preliminary analysis as Robson (1993:377) advised. This is not easily achieved admits Miles & Huberman (1984:54) since qualitative research is recorded in terms of words and not numbers. The words are fatter than numbers and have multiple meanings. To classify the words, Miles & Huberman (1984:56) suggested the use of codes which are abbreviations or symbols applied to sentences or paragraphs conveying an idea. In my case, I used coloured adhesive discs to make important points so that they could be easily identified for tracking purposes at some future stage.

2.6. Conclusions

Abagi (1995:13), quoting Anderson (1988), Majchrzak (1984) and Nachmias & Nachmias (1982), argues Social Science research is a problem solving exercise to acquire a body of reliable information about a social phenomenon to explain, predict and understand the phenomenon. This body of knowledge may then solve a problem and improve people's welfare.

If this is the case then the problem I am trying to solve is to improve science education. To accomplish the task, I consider research to be an essential. Since schools are complex environments, to do justice, qualitative research is vital using the instruments of interviews, participant observations, journals and physical artefacts which are to be complemented by questionnaires.

Chapter 3 : The St Sebastian's Case Study

3.1. Introduction

The case study begins with a description of St Sebastian's College : its resources, its personnel and the mission they strive to fulfill. Following are two vignettes. One concerns itself with an interview with a science teacher and a description of a science lesson he conducted for grade 10s. During the analysis I tried to contrast what was revealed in the interview with events which transpired in the lesson. The second vignette focuses upon the analysis of a laboratory practical session organized by another science teacher at the school. I attempted to explain events and raise issues pertaining to the lesson as it related to what came to the fore in the interview. Since the practical session exposed severe weaknesses in this teacher's methodology, I recommended a process approach based upon the opinions of the experts. I then account for the curriculum of St Sebastian's according to a 'structure of the disciplines' perspective and contrast this with a somewhat opposing perspective which I struggled to adhere to, namely, the cognitive perspective. Thereafter, is a description of the course which I designed and its accompanying rationale which stressed a process approach because it juxtaposed with the ideal of scientific literacy. However, my social constructivist teaching methodology was vehemently opposed, revealed in a practical demonstration which I described. This description then raises the issues of control, time, importance of results to the St Sebastian's school boy and the viability of developmental assessment in the product oriented milieu of St Sebastian's.

3.2. St Sebastian's College in context

St Sebastian's College of Buxley in the Eastern Cape is described in an advert posted in the EP Herald (May 1998) as "One of South Africa's finest schools." They are currently in a phase of expansion and development while preparing pupils to be leaders in the 21st Century.

Apparently St Sebastian's has been experimenting with curriculum innovations for the past three years. For this reason, I was immediately granted permission to conduct research when I presented my suggestions to the administration in October 1997. Much will be said for the research during the course of this case study, but for the time being, I wish to provide the reader with some insight into the background of the learning environment.

St Sebastian's College Campus Plan

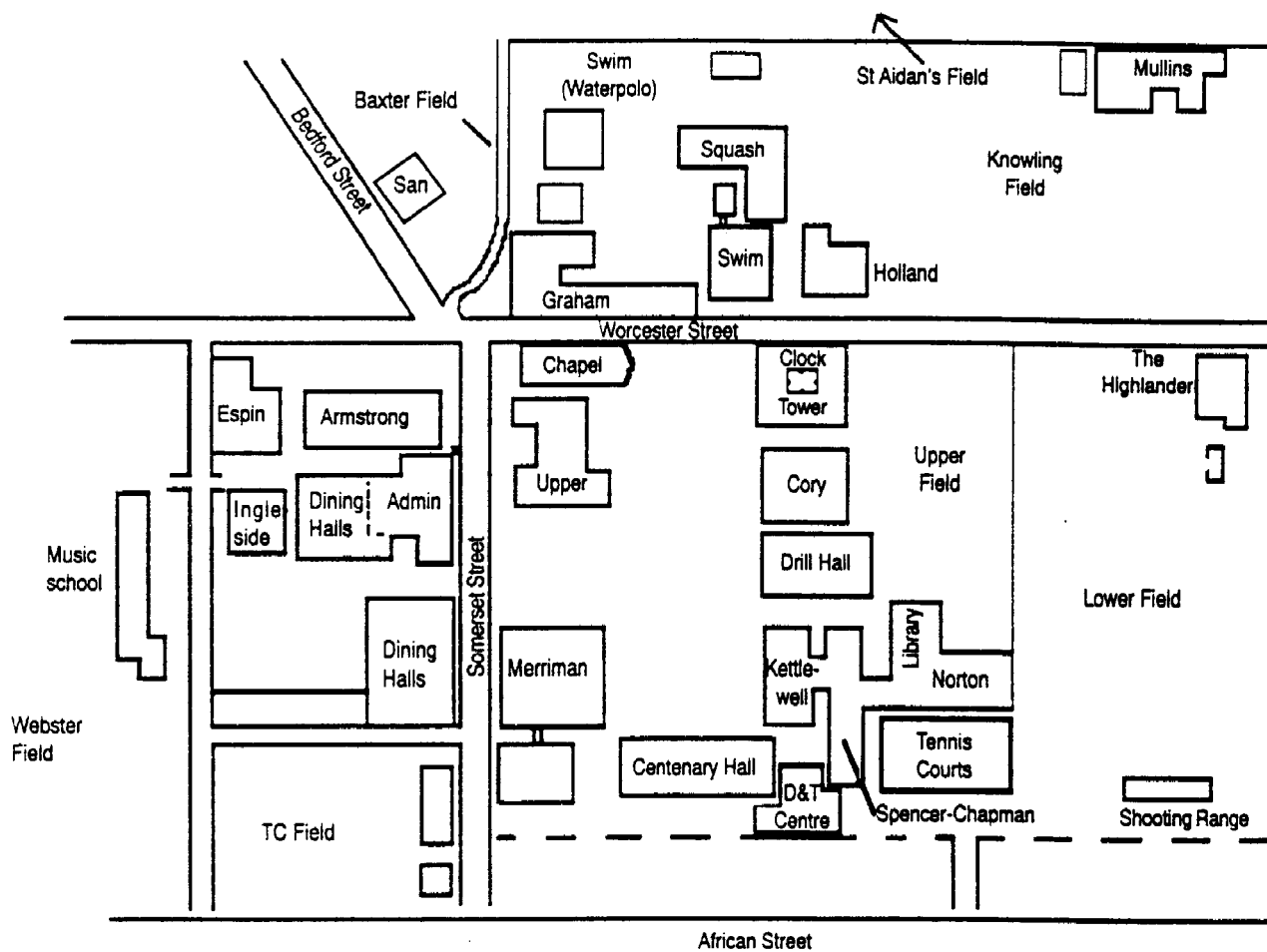


Figure 3.1



3.1 Clock Tower



3.2. Lowerfield – looking outwards
towards the town.





3.4. View of ch



3.5. Armstrong



3.6. Upper



3.7 Labora
being used for
practical sessio



3.8. Store
full of chemica



3.9. Classroom havin
to computer and
television faciliti



3.10. The library



3.11. The library



3.12. Arthur Cotton Design & Technology Cen

What justifies the school in rating itself among the top draw of schools in the nation? Having been educated in a similar 'privileged' school, I can cite four reasons for this:

- (i) the beautiful environment in which the school is located,
- (ii) the quality of the teachers,
- (iii) the excellent record of matriculation pass rates over the years, and
- (iv) the superfluity of resources.

I will now consider each of these points to place the school in its context.

3.2.1. The environment of the school

The ivy-clad stone walls, the chapel and clock tower, the well manicured lawns of the playing fields, the spacious gardens and well-maintained flower beds all blend together to create the impression of the ideal learning environment.

Pause for a moment and glance through photographs 3.1-3.6 in correspondence with a map of the school. You will not fail to remark upon the superb architecture of the school; the beauty of which is greatly accentuated by the sunshine of a warm afternoon in autumn; the season touted as the most beautiful of the year in Buxley.

3.2.2. The highly qualified staff

The staff all have impressive qualifications. Out of a total staff of 43 in 1996, one teacher had a PhD, seven had Master's degrees which may have supplemented teaching diplomas, 8 had Honours degrees which may have supplemented teaching diplomas while 27 had first degrees and/or diplomas. In comparison with other schools, government or private, St Sebastian's can take pride in their esteemed teaching personnel.

3.2.3. The excellent matriculation results

On visiting the office of the deputy headmaster, I learnt that the mission of St Sebastian's was to produce pupils with a matric exemption. If this is their mission then the results of 1997 proved to vindicate their purpose. 89% of pupils who wrote the matric exams passed with exemption.

3.2.4. The supertfluity of resources

For the teaching of Science, St Sebastian's is well resourced. The school makes use of three fully equipped laboratories, well supplied with the necessary apparatus and chemicals.

Photograph 3.7 shows a laboratory being utilised in a practical session. Photograph 3.8 shows a storeroom full of chemicals. The three laboratories and one physics classroom all have the benefit of a computer and access to a television and video recorder. This is shown in photograph 3.9. In addition, pupils and teachers may make use of a library (photographs 3.10 and 3.11), stacked with over 13 thousand books, not to mention CD ROM. Perhaps, what makes St Sebastian's the *crème de la crème* is the Arthur Cotton Design & Technology Centre. Learners from all departments make use of the lecture theatres and workshops in the construction of various technical artefacts. Photographs 3.12 depicts the centre.

In order to send a boy to a school of this prestige, beauty and stature, parents need to be prepared to pay a high price. Fees during the 1998 academic year amounted to R39 000 for a College boarder and R27 000 for a day scholar. St Sebastian's is therefore an elite school and not unjustifiably reputed to be a pocket of excellence.

Since I was a visitor in the school with my "new-fangled ideas", I deem it appropriate to present two vignettes of the school so as to provide the reader with an impression of the school, behind the ivy-clad walls, so to speak. These two vignettes centre around Science classes and from a research methodological point of view may be described as passive uninvolved observation. The first concerns a grade 10 lesson of Mr Andy Christianson whose class is studying the topic "parallax shift". The second is a grade 8 practical session under the control of Mr Robinson where their topic is that of density. These two vignettes will expose the environment in which I tried to implement a more social constructivist course. This course and the issues it raised will be discussed thereafter.

3.3. Vignette 1 Mr Christianson's lesson on parallax shift

The following vignette portrays an interview and a lesson conducted by Mr Andy Christianson – the head of the Science Department at St Sebastian's College. The lesson was scheduled 1½ hours before the interview. On reviewing the evidence, I made a close analysis of Andy's views on education in relation to his practice in the classroom.



Andy with class by the rugby field. The class is not consulting notes. They are unengaged while listening to Andy who is the centre of attraction.



3.14



3.15 Andy using the shadow of a rugby post to determine the height of the rugby posts using ratio and proportion.

On Andy's request I presented him with an interview schedule a day before the interview. Before the interview commenced, however, he affirmed that he did not have time to study the schedule. I believe Andy's comments in the interview and his performance in the classroom were not contrived. The lesson which I observed focused on a co-ed group of grade 10 learners and the Physics topic was "parallax shift".

For the purposes of this discussion I will alternately consider aspects of Andy's interviews in relation to what was observed in his lesson. I would classify my research as passive uninvolved observation making use of field notes, recorder and camera as recording instruments. The first significant issue concerns Andy's epistemology.

3.3.1. Andy's epistemology

After the term "epistemology" had been explained, this was Andy's opinion on how learners develop knowledge and the circumstances which promote this structuring process.

Andy:

I think that education has to be seen in terms of the learner who is ... eh ... learning and he obviously has - every learner has some, made some sort of sense of the world - even though it is not actually the way things work. And I in education, we need to be able to go along with the process to modify their understanding of the way the world works ... um ... the process by which that happens is very important. They actually allowed to get a chance to express their ... eh ... understanding of the way the world works ... if not eh full picture, an incorrect picture ... um. If they don't if the time and the constraints sometimes, being presented with and the big question and the crunch comes in when their preconceived ideas to adopt someone else's without discovering it for themselves ... That's the crunch. So obviously the more they can discover for themselves the easier it is for them to overcome their preconceptions stroke misconceptions ... um, and I think learning, learning takes place from where they are at ... um ... and in a complex situation then to build bridges towards ... um ... abstract

eh. They ... you actually have to find where they are at, before you can actually get them to build bridges to ... that ...

Interviewer: In your teaching practice, where have you tried to make or understand where the child was at in order to take him further along the road?

Andy: Um ...

Interviewer: What sort of policy do you have in that regard?

Andy: Well, ... um ... I get them ... to ... to ... write quite a lot down of their own understanding of the work in Science essays. They write quite a lot of science essays. I have quite a few files of the better ones, and they they, also I get them to discuss in groups, to put it in their own words ... what is happening and to argue amongst themselves and I come around and listen to their arguments. They by, sort of a ... a ... 'socratane (sic) dialogue, I ... of they say this then I say if that is the case then that will be the case ... and this and this and this ... leading them to the absurd, based on their misconceptions and then get them to, as a class, often come up with alternative solutions. That's ... um ... not really one-on-one, except through the written work. One-on-one takes place in those "buzz groups" and then end with a class discussion where they discuss to ... discuss with me, sort of socratane (sic) dialogue ... where I put their I present them with their own ... sort of like reflective listening. Feed them back what they are saying to me in a slightly different context. Would they mean this until they see that perhaps there is this not the full concept ... and try and get them as a class. Often it is a jointly

owned thing ... rather than a personally owned thing. So, I mean that ... um ...

The transcript of Andy's interview reveals the strong commitment and orientation which he has towards social constructivism. Note how Andy acknowledges that each child has prior knowledge which needs to be recognised. More significantly, note the emphasis which Andy places upon writing, socratic dialogue and "buzz groups". It is through this medium that children can voice their thoughts and so engage in the restructuring process which the learners' peers or the teacher himself may initiate.

In reviewing the lesson which Andy conducted in relation to Andy's epistemology of social constructivism, I cannot help but notice, the stark contrast. For most of the lesson, Andy was the centre of attention as opposed to the learner being the focus.

After introducing the lesson, he set about a lengthy lecture on the principle of parallelax shift. He tried to relate the concept to a practical example of its usage in the destruction of a dam in Germany during the Second World War. The only real input from the class came in the occasional response to Andy's questions and in transcribing the definition of parallax shift. Towards the end of the first half an hour, Andy asked the class to take down the following sketch (figure 3.2) as it related to the practical demonstration which was to follow.

The aim of the exercise was to go out onto the rugby field and from the vantage points of the pavilion steps at B and the pavilion wall at C, look outwards towards the pylons (at R), some 10 kilometres away. Then using the principle of parallax shift, it would be possible to determine by similar triangles, the distance between B and A.

While still in class, Andy explained the principle of parallax shift and what was to be done in the demonstration in relation to the sketch while the pupils were copying down the information. Andy proceeded to develop his logic to the formula stage which had the following form:

$$AB = \frac{0,5 \times 10}{FP} \quad (1)$$

Consider the diagram

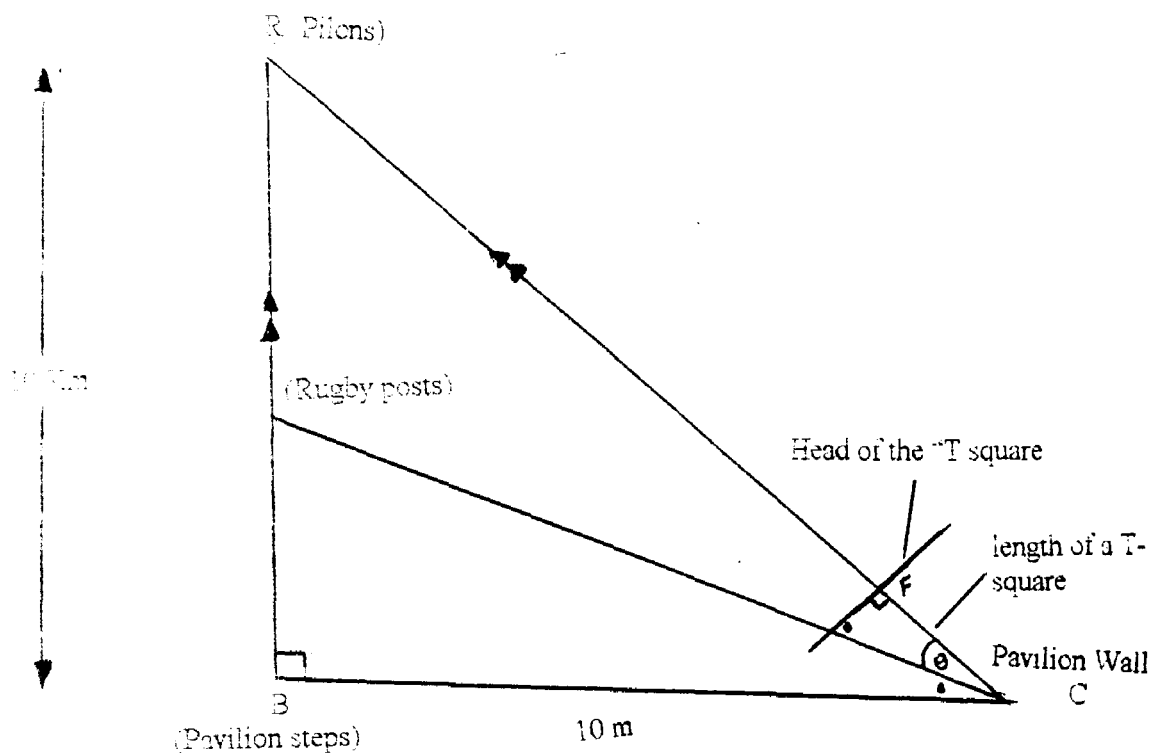


Figure 3.2

Triangular diagram used in parallel shift practical

What was interesting to note was Andy became more hurried and impatient immediately before the learners were scheduled to go down to the rugby field. This is because they only had another 13 minutes before the end of the lesson and the demonstration was quite involved. Consider Andy's comment: "Now, I want us to get to the field promptly. So if you could move it up!"

When on the field I took various photographs of Andy and the class which the reader may peruse alongside.

My first observation is Andy is always the centre of attention. Whatever happened to that learner-centrality, you might ask? The learners are generally standing around with hands in pockets, hands on hips or with folded arms. Worse than this, the reader will notice in photographs 3.13-3.15 that no books are open and hence the learners are not relating the

practical situation which they are viewing to the fairly involved triangular diagram depicted earlier and the confusing formula (1) which Andy had derived.

My summation of these events after careful analysis of the interview lesson transcripts, observation notes and photographs is that Andy is a victim of his circumstances. I believe he is sincere in trying to follow social constructivist principles in his teaching practice and may even use them to a limited extent, depending on the situation. However, Andy is compelled to schedule lessons to remain within a tight framework dictated by 43-minute periods. Although not articulated clearly, Andy refers to this problem early on in our interview:

Andy: If they don't, if the time and the constraints sometimes, being presented with and the big question and the crunch comes in when their preconceived ideas to adopt someone else's without them discovering it for themselves....

Andy's lesson on parallax shift certainly illustrates this "crunch" where learners were not given the opportunity to discover anything. They were imposed upon. They were not asked to explain the concepts to each other, work in teams or take measurements for calculation purposes and so find the distance between the pavilion and the rugby posts. They simply did not have the time. I would have suggested an hour to an hour and a half of intense field work for success to be realised by all the learners if OBE principles were applied.

In all fairness to Andy, I only observed one lesson and therefore we can hardly be too critical of him on the basis of a single lesson. Perhaps, the next day he may have had a more learner-focused lesson. This may be the case, but the transmission approach to teaching which is so characteristic of traditional schooling, was certainly manifested in Andy's general lesson approach.

In the interview, I asked Andy whether he would be prepared to involve a prominent authority, outside of St Sebastian's, in assessment in an OBE system. Andy immediately referred to the case of Professor Eddie Barlow, a State witness, who had been invited to St Sebastian's to present a topic on road accidents while relating his evidence to various Physics concepts, for example, equations of motion. Study Andy's words carefully.

Andy: ... Professor Eddie Barlow is a State witness and we have had him here before to *talk* about Physics of motor cars and the dangers of our roads ... but from an evidence point of view ... using graphs and equations of motion to *talk* about road safety ...

The point I am making here is Andy's incessant use of the word 'talk'. Once again when asked about subject integration, Andy used the following words:

Andy: We can get people from other departments, to actually *talk* to science class. What it means, a particular aspect ... we can get the Geography department ... to come in; the History department to come in, to *talk* about the history of how Galileo ...

An interesting point to ponder as I conclude this vignette is not only the difference between Andy Christianson's stated epistemology and his teaching practice, but also the consistency of Andy's approach with that of the behaviourist paradigm, an example of which is Fundamental Pedagogics. Andy considers the learner to be in a less prominent position than the authority State witness or his colleagues from other departments. The learners are reduced to recipients of knowledge as opposed to ones who can engage in knowledge construction in a course facilitated by the experts. Based on the evidence which I have constructed for the reader, I conclude that what is in Andy's head may not be in his heart – as sincere as I am sure he is.

3.4. Vignette 2 The practical lesson of Mr Robinson

When I started my field work at St Sebastian's I was invited to the staff room for tea and introductions. During the course of conversation with a Mathematics teacher, he proudly declared: "We've been teaching in an OBE-sort-of-way for years now."

The year before (1997), I happened to read a report in the local Buxley newspaper – Grocott's Mail. The article posted in late October '97 was entitled "Struggling to find our educational direction and meaning." It concerned a record of Mr Butler's (headmaster) address to the school and dignitaries on speech day. One particular sentence caught my eye. It read: "St

Sebastian's was already developing a hybrid which blended OBE into its own methodologies."

I was intrigued by this statement and the conversation with the Mathematics teacher revealed that new innovations in the St Sebastian's curriculum were afoot for the past three years.

During the course of my field work, I interviewed Dr Johan Robinson – a science teacher whose tenure as head of department had recently expired. He is one of the doyens of the College, having 18 years of teaching experience and yet modestly reminded me that he never had a teaching diploma. Notwithstanding this deficit, Mr Robinson is obviously a man of considerable experience and integrity who demonstrated an unflinching loyalty to St Sebastian's.

One of my first questions posed to Mr Robinson was to explain the meaning of Mr Butler's comment. This was his reply:

Mr Robinson: My interpretation of that is that St Sebastian's has over many years now encouraged experimentation in teaching. We have the minimum of red-tape and [are not] directed exactly how and what we should teach – so there has been the freedom to try new ideas. If they work: well-and-good. If they didn't: well, we still learnt something. There has also been, over the years, an increase in interest, in other methods of assessment ... there has been a growing awareness and interest in group work ...

From this statement, it is plain that a very sound relationship of trust exists between the administration and the teachers. If there is free reign to implement changes in the curriculum and still make mistakes without fear of accountability then much can be said for a truly democratic dispensation at St Sebastian's.

The second point to note is the interest and priority which the school apportions to group work and assessment. For the purposes of the following discussion, I will focus upon group work. My particular interest is the way Mr Robinson envisages group work in terms of

classroom management in comparison with events which transpired in one of his grade 8 classes.

To encourage Mr Robinson to explain his policy toward group work, I asked him the following question in the interview:

Interviewer: In terms of your own teaching, you having been at the school for 18 years ... um ... let us go back 12 years, how was it different then to what it is now ... um, you have mentioned the aspect of group work ... could you narrow it down to a particular example. How would you have approached the topic of density then, as opposed to now ... or has it been fairly consistent?

Mr Robinson: No, I think in my own teaching I encouraged more forcefully those pupils to work together. I have always done that, but I am more and more aware of the benefits to be gained by that and I will try more and more ... to give opportunities where they can have group work – both in terms of worksheets, practicals and also questions which they asked, which I encouraged them to discuss with each other, rather than to ask me immediately what the answer is.

Later in the interview we continued with this theme and Mr Robinson elaborated more fully upon his role in relation to groups of learners in the learning process. These were his comments:

Mr Robinson: I have a sneaking suspicion that pupils can teach each other more effectively than I can provided they are doing it seriously and that they think carefully what they are saying and what they are doing ... I very often ask individual pupils to teach other pupils, say a question has cropped up in class on occasions that groups of pupils have been struggling with and haven't been able to get the answer. I will happily explain it – one or two of the group, but if another individual or group of pupils asks the same question I will very often ask one of the original members to come and explain it to the one who has asked the question. As a safeguard, I normally hover in the background

just in case there are still misconceptions and I will try and prevent misconceptions from being propagated.

Before progressing with a description and critique of events which unfolded in a practical session involving grade 8s, I would like to pause for a moment and ponder the words of Johan Robinson. Mr Robinson, in describing his practice of hovering in the background, waiting to pounce upon misconceptions to prevent their dissemination reveals his positivist epistemology.

Glasson & Lalik (1993:182) explain that positivists believe it is possible to use theory, together with value-independent observation and logic to discover phenomena that purportedly exist in the real world. The goal of science for positivists is to achieve an isomorphic relationship between human knowledge and the natural world. In Mr Robinson's case, if this relationship was not immediately apparent, represented by what he calls "misconceptions" then it is time to step in and remedy the situation,

Glasson & Lalik (1993:188) then quote Glasersfeld (1989) who, speaking from a postpositivistic perspective, describes knowledge as a collection of conceptual structures which are viable within the learner's range of experience. The obligation of teachers operating from this perspective is to find ways to understand students' viewpoints, propose alternative frameworks, stimulate perplexity among students, and develop classroom tasks that promote efforts at knowledge construction [Glasson & Lalik (1993:188) quoting Vosniadous & Brewer, 1987].

The Glasson & Lalik (1993:187-207) article refers to their study which examined teachers' changing beliefs and practices when the transition from a positivist to a postpositivist perspective was made. One of the teachers observed was Martha who initially expressed the positivistic view that the goal of science instruction was for students to arrive at scientifically acceptable conclusions. As she explored social constructivist principles, documented in Glasson & Lalik (1993:201), she noticed a tension between her efforts to present correct scientific explanations and giving learners opportunities to develop their own understandings. Indeed, similar to Mr Robinson, Martha valued learner dialogue because learners seemed to learn faster. Yet, her apprehensions were aroused when she had to acknowledge the import-



Mr Robinson demonstrating the laboratory equipment to learners before a practical session.



3.17

Billy (nearest the camera) takes command of the group while Sam (next to Billy on far side) is his assistant.



3.18

Tom shown nearest the camera.

ance of student talk and ideas, even when having to face scientifically unsound arguments on the part of the learners.

If social constructivist philosophy has credibility then Mr Robinson would be advised to rather tolerate a child's misconceptions for a short while. Thereafter, Mr Robinson is to devise situations where a child struggles to account for observations with his or her existing framework (mental structure) and hence will readily alter his or her current framework to embrace a more appropriate understanding. This is far removed from Mr Robinson's current practice of concept elimination and replacement.

I now wish to describe a practical session conducted by Mr Robinson. The class of grade 8s engaged in a practical session entitled "Sink or Float?" It involved determining which materials would sink or float in water and then relating their findings to the concept density. The discussion is once again accompanied with photographic evidence.

3.4.1. Description and analysis of a practical session involving grade 8s

3.4.1.1. Description

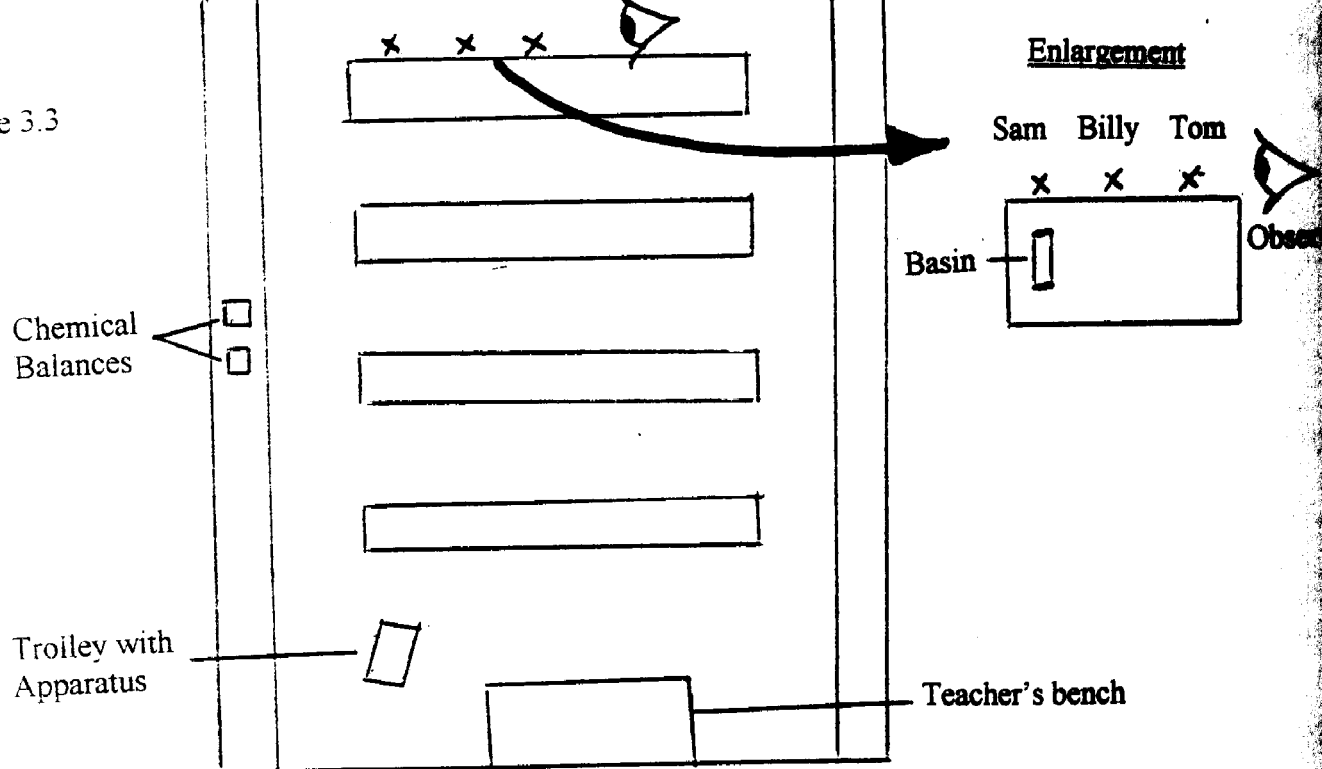
At the start of the practical Mr Robinson asked the class to turn to pages 19 and 20 of their typed notes and he requested that they do the investigation in groups of three.

Mr Robinson, seen in photograph 3.16, then gave the class a perfunctory demonstration at the front of the laboratory indicating which materials were available and how to use the displacement cans. The masses and corresponding volumes of the objects had to be determined and their densities found. The whole idea was for the learner to progress through the prescribed practical step-by-step, and then finally conclude that if a material's density is less than water, it floats; if greater than water, it sinks.

I decided to unobtrusively observe a group of learners at the back of the laboratory. To give the reader an idea of the group's location, peruse figure 3.3.

Consider photograph 3.17. I noticed that the group fell under the leadership of Billy, a highly motivated Chinese learner located nearest the camera on the right. He was closely assisted by Sam who is seated to the right of Billy. Sam was observed to be the scribe for the group and occasionally helped Billy with the arrangement of the apparatus.

Figure 3.3



Target group in relation to the rest of the

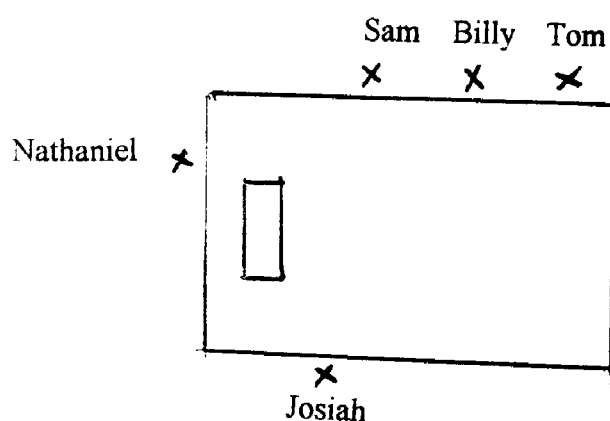
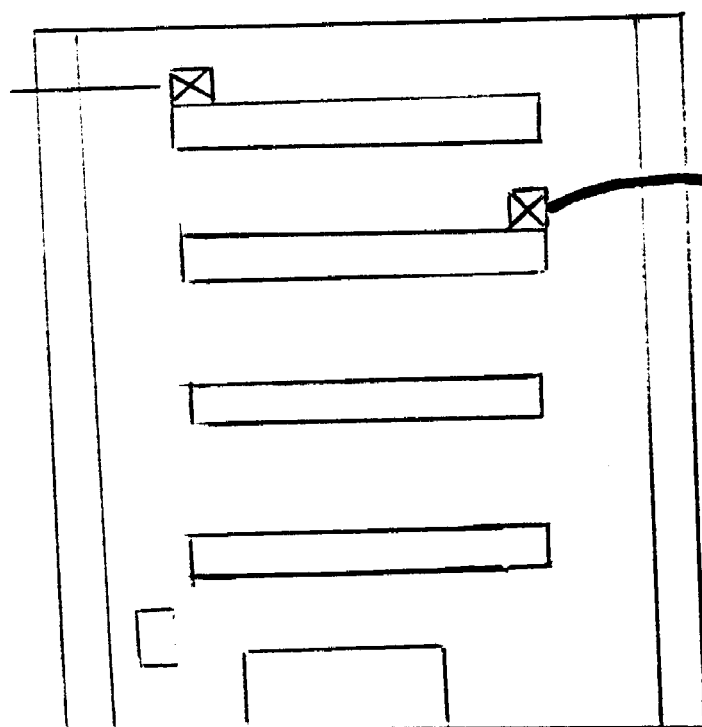


Figure 3.4

Position after additional members joined the original group

Original Position of the Group



Enlargement

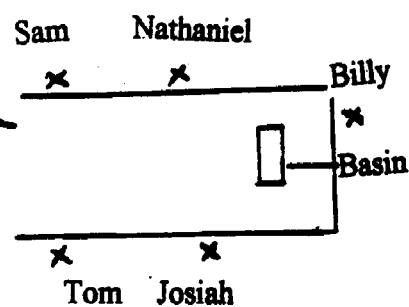


Figure 3.5

New position of group after relocation

3.19

Sam measuring a volume



3.20



Learners in group engaged
in horseplay



3.21

3.22



Water near basin forces learners to move to a "drier" part of the laboratory

3.23



Learners in new position in laboratory

3.24



Learners of target group huddled around a sink



3.25 Learners continue to engage in horseplay to the chagrin of the teacher



3.26 A learner filling in a prepared table in the handout

Initially there were only three in the group, the third learner Tom who is seen nearest the camera in photograph 3.18. I noticed from the start that Tom was not the least interested in the practical, showing signs of boredom. He began to play with the apparatus and then used the measuring cylinder to make a flute noise.

Now study figure 3.4. Within four minutes from the start of proceedings, two more learners forced their way into the group. These were two Africans, whom I have given the pseudonyms: Josiah and Nathaniel. Billy, Sam and Tom remonstrated against their inclusion, but they were adamant and so they remained.

Billy and Sam made a serious attempt to follow the steps of the practical and perform the prescribed procedures. Here we see Sam in photograph 3.19 determining a volume while Billy went to measure the mass of an object on the chemical balance. Tom, Nathaniel and Josiah became more boisterous and started splashing water on the bench. Evidence of their horseplay activities is betrayed in the photographs 3.20 and 3.21 where the culprits are seen to be laughing. Eventually the situation, shown in photograph 3.22, became intolerable since there was water splashed all over the working area near the learners' notes. This compelled the learners to relocate to another "drier" part of the laboratory shown in photograph 3.23. Their new position in the laboratory is indicated in the figure 3.5.

During these events Mr Robinson was trying desperately to maintain some semblance of order. His blood pressure was rising by the minute. The following passage of interaction between Mr Robinson and the class illustrates my point and captures the "atmosphere" in which learners were expected to work.

Mr Robinson: Please guys notice, millitres and cubic centimetres are the same thing.

Just then a learner broke a glass displacement can nearby to the appreciation of the group.

Mr Robinson: What's happened!? I told you to use the aluminum can ... [To everyone] I hope you are all writing up the results in your notes. I expect you all to have a table [said to my group]. [He continues] Gentlemen, could I just have your attention please. Everybody

please ... It must have been you in this classroom about two weeks ago ... Sam found a spatula that had been broken.

Learner 1: Who?

Mr Robinson: My lab assistant ... a spatula that had been broken. Who did it?
Who did it?

Learner 2: What is a spatula, Sir?

Mr Robinson: A spatula is a little spoon thing which should have been like this
[holding it up] ... but somebody has bent it, has tried to mend it.
Who did it? It was one of you in this class. Pardon ...

Learner 3: Maybe it was another class.

Mr Robinson: It was found in the class after you had been. The previous class,
somebody saw it completely whole ... unbroken and then you guys
came in and somebody broke it. Can I please ask: "Who did it?"

Mr Robinson continue to chide the learners for not owning up and finished off with the following comments:

Mr Robinson: It is a symptom of this age, it is a symptom of this country. It is a pity that somebody doesn't have the guts to own up.

It seems that Mr Robinson was not hovering in the background waiting to pounce on somebody's misconceptions. However, he then allowed the class to continue while admonishing my observed group who are seen in photograph 3.24, huddled around a sink.

Mr Robinson: Please don't fill up the sink Billy. What are you guys doing?
[photograph 3.25] How are you going to do that? Please don't put wet things on the balances ... Please don't reset the balance on the left.

All this frenetic dialogue on the part of Mr Robinson serves to illustrate the difficulty in which he found himself. It was close to the end of the period, the clock was ticking away and most members of his class were undisciplined. His final announcement, when the bell was about to sound, was the following:

Mr Robinson: Are you guys interested in working or not or are you just fooling around? Have you done the notes as well? Please will you put all your objects on the towel so they can dry out ... right put these things away now. [Bell goes ... learners snatch their satchels and run off leaving their wet apparatus in a mess on the bench].

3.4.1.2. Analysis of Mr Robinson's laboratory and lesson approach

Roth (1994:198) provides a vivid description by Gallagher & Tobin (1987) of a situation in science laboratories which emerged from ethnographic studies in traditional high schools in Australia and America. The authors discuss several elements as constitutive for the problems with laboratory teaching. These problems are enumerated below followed by my own commentary related to the teaching of Mr Robinson.

3.4.1.2.1. Problem 1

Experimental tasks often embody a cookbook approach. Students follow recipes gathering and recording data without a clear sense for the purposes, procedures and their interconnections.

3.4.1.2.1.1. Commentary

Mr Robinson provided learners with typed notes, specifying the procedure to be followed. It was clearly a cookbook approach. The learners in the class were expected to follow these steps on page 19 and record their data on page 20 in the table provided. Photograph 3.26 illustrates this point. Very little thought on the part of the learner went into making sense of the purposes and interconnections necessary to understand the experiment. The situation was aggravated by the misbehaviour of the learners.

3.4.1.2.2. Problem 2

The tasks presented to learners have low cognitive demands and provide a context that precludes reflective thought and concentration.

3.4.1.2.2.1. Commentary

Since Billy and Sam were the main role players in conducting the experiment, and there were only limited items of equipment which could be handled, and the procedures which had to be followed were not that intricate, Tom, Nathaniel and Josiah were immediately alienated, become disengaged. Their misbehaviour contributed towards an unpleasant atmosphere and Dr Robinson's aggression towards the end of the lesson was indicative of it.

3.4.1.2.3. Problem 3

Learners spend much of their laboratory time in off-task activity with short periods of attention to get the work completed. The time off task is used for non-science related socialization with peers all over the classroom.

3.4.1.2.3.1. Commentary

This was clearly the case with Tom, Josiah and Nathaniel splashing water, making flute noises and generally making every effort to derail the experiment. My recommendation is that more attention must be given to assigning group roles and activities so that everyone is contributing..

3.4.1.2.4. Problem 4

To make up for the time lost in these activities, teachers set a high pace in regular classroom periods to transmit factual information.

3.4.1.2.4.1. Commentary

In the case of this practical, learners needed to be able to plot results on a graph. Mr Robinson spent a whole period, about two weeks before, lecturing on the method to plot a graph. I taped the lesson and after transcription, it amounted to 18 pages of teacher instruction with little input from the learners.

3.4.2. A recommendation for an improved lesson

After the lesson I spoke briefly to Mr Robinson about his impressions. He was clearly disappointed with events and conceded that the lesson was not successful.

To overcome the problems discussed earlier I have a recommendation: Adopt a process approach to science teaching. I will now investigate this matter in more depth.

3.4.2.1. A process approach

On one occasion I questioned Mr Robinson about the possibility of introducing a process approach into his lessons. His reply was he doubted the ability of a grade 8 to the extent that they had not developed to the stage of being research scientists. He would never be reconciled to such an approach. His sentiments on the matter were confirmed in his written evidence generated from the questionnaire which I had compiled. He selected the lowest rating of "1" on a Lickert Scale of 1-9 concerning whether he stressed a child's ability to use process skills in designing his or her own experiments. Concerning a grade 8's ability to design their own experiments, Brotherton & Preece (1996:65-74) would disagree with Mr Robinson for his lack of faith in his learners. These researchers investigated the teaching of Science with a special emphasis on process skills with year 7, 8 and 9 classes. Their study employed experimental and control groups. The most significant finding to emerge after the 28 week study was the effectiveness of the intervention. It was shown that year 8 classes were capable of using process skills in the design and performance of their own experiments.

The premise of the 'process' model, explain Gott & Mashiter (1991:58) is that Science places more emphasis on methods than on products. These methods or processes include: observing, classifying, describing, communicating, drawing conclusions, making operational definitions, formulating hypotheses, controlling variables, interpreting data and experimenting.

In short, learners are placed in a situation where prescribed 'cook-book' experiments are no longer the *modus operandi*. Rather learners are faced with a problem which Gott & Murphy (1987), as quoted in Gott & Mashiter (*ibid*), define as one in which the pupil cannot immediately see an answer or recall a routine method for finding it. The learner must set about following a set of procedures such as identifying variables, controlling variables, experimenting, tabulating results, analyzing and generalizing conclusions.

Millar (1991:50) takes the argument a few steps further. It is not sufficient merely to teach the processes of Science for their own sake. The challenge is to design and facilitate a curriculum which is personally valuable and worthwhile enough wherein a learner will be

stimulated to use the cognitive skills to understand scientific concepts and make sense of their world. In other words, the processes are a means to an end. To extend upon this notion, we use the processes in a bid to understand the scientific ideas and concepts. Indeed, I agree with Millar and initially I attempted this approach in designing my own curriculum but collided head-on with several systemic problems. I will now turn my attention to explaining my own lessons and field work at the College in order to reveal the impracticalities of introducing an OBE curriculum within a traditional system.

3.5. Introduction: A process approach to the curriculum

At the start of 1998 I was given responsibility for piloting a new “OBE Science course” for one class of grade 8 learners at St Sebastian’s. My initial understanding was that I had carte blanche authority to implement any radical changes that I thought would reorient the existing situation towards an OBE system. Within one month I was compelled to refocus my approach so that it was more in keeping with the existing programme. Why did a promising opportunity degenerate into such an embarrassment? I can identify two reasons. First, I was not cognizant of how deeply entrenched the traditionalist system was at St Sebastian’s, evidence of which is provided in the two vignettes. I did not analyse the existing curriculum thoroughly enough and I naïvely believed that the school was anxiously awaiting the paradigm shift which OBE promises. I did not realise that the existing organization of the school exerts an enormous influence upon the curriculum and the teachers’ and learners’ entire thinking was controlled by it. This is one of the central observations made by Spady of the time-based structure prevalent in traditional schools which I discussed in chapter 1. Yet, as fundamental as it was, I failed to be realistic, hardly giving it a precursory glance. Second, when designing my course, my requirements and expectations superceded the ability ranges of the learners because I did not pay attention to their developmental level. In short I have to be held accountable for the shortcomings of the course. It was not the fault of St Sebastian’s that I was so unrealistic and naïve. In the latter part of the case study it is my intention to analyse the existing traditional curriculum of St Sebastian’s in relation to what I envisioned. This is the very essence of the thesis itself – to illustrate how impractical it is to accommodate two fundamentally different educational philosophies within a single school framework. I hope to achieve this end by relating the events which occurred as I observed them and in the words of the role players as I recorded them.

3.5.1. Opposing perspectives on education

The perspective of education held by St Sebastian's is best described by Posner (1992:95) as 'the structure of the disciplines'. According to this perspective, the primary purpose of education is the development of the intellect (King & Brownell, 1965) and the disciplines of knowledge constitute the content best suited for this intention. It is believed that each discipline has a distinctive structure, and acquiring this plurality of structures is given the highest priority in schools.

The piece of evidence to support my view that 'the structure of the disciplines' is paramount in the administrative policy of St Sebastian's is located in the existence of a time-table. Below (figure 3.6) is a typical example of a grade 8 boy's routine schedule.

Timetable of a grade 8 learner

PERIOD						
	TUES	WED	A	B	C	D
1	A	Fre	Div	A	Hist	Geo
2	Geo	M	Hist	E	E	A
3	E	D&T	D&T	Com	GVi	M
4	E	A	M	Med	Geo	Sci
5	M	E	Fre	M	Art	Fre
6	BS	Hist	E	Sci	M	D&T
7	Art		Geo	Fre	A	E
8	Sci					

Figure 3.6

I will now focus attention upon a competing perspective labelled by Posner (1922:109) as the 'cognitive'. Inherent within this perspective are the concepts: integration of subjects, existence of naïve theories, recognition of prior knowledge and the integration of the departments.

3.5.1.1. The integration of subjects

The 'cognitive' perspective is consistent with social constructivism and is far more holistic as opposed to the fragmentary approach of the 'structure of the disciplines'. Resnick (1983), as

quoted in Posner (*ibid*), summarises the perspective with the notion that learners construct their understanding and look for meaning and regularity and order in the events of the world.

This can be achieved, I believe, with a holistic approach rather than dividing the curriculum into separate subjects. There are definite benefits in treating the curriculum in this way. Posner (*ibid*) who quotes Resnick (1983) states that the one reason for this is learners can make interconnections between the subjects so as to tie bits of information into clusters which are organized into schemata. This is what I attempted, but the mind-set of teachers at St Sebastian's resisted any cross-pollination of the disciplines. These were the views of Andy Christianson:

When faced with a theme – how you deal with situations in that theme, as opposed to a, sort of a content based and direct way through the syllabus ... um ... I, that, that, could pose a problem. That's because there are certain subjects, a very much ... the logical sequence of dealing with topics is quite, eh ... fixed. One subject will have its logical order, while other subjects will have their logical order.

3.5.1.2. The existence of naïve theories

Resnick (1983), as quoted in Posner (*ibid*), continues with the comment that with this construction process will emerge certain naïve theories, which is an integral part of the learning process. These naïve theories result when the learner has not fully integrated complete knowledge of the situation.

Gavin Cook, another science teacher at St Sebastian's, expressed some reservations about this attribute:

In Science, if they actually come to a wrong conclusion it is incredibly difficult to convince them that their conclusion is wrong and to um ... adjust their conclusion to what is alleged to be the correct conclusion..

Reading these comments, I immediately conclude that Gavin's classroom practice is transmissive by nature so as to prevent learners from getting the wrong end of the stick. My

approach of having free conversation would therefore conflict strongly with traditional pedagogy.

3.5.1.3. The issue of prior knowledge

Resnick (1983) as quoted in Posner (*ibid*), then raises the issue of prior knowledge and how important it is to acknowledge its existence. The reason is a reciprocal relationship of evaluation exists between the incoming knowledge and the present schemata. If cognitive dissonance results then the restructuring process begins and continues until accommodation is effected.

The issue of prior knowledge and its recognition by St Sebastian's staff as being important was contested by Gavin Cook. During a departmental meeting, Gavin warned that, "we have to be careful of this thing called prior knowledge". He related a story of a friend who said that a boy in his class was asked to explain the procedure involved in the production of maize. The boy then explained the farming process and as a climax to the narrative, the boy purportedly declared that, "once bagged, it was ready to be stolen!" The inference being that Gavin expressed some deprecation towards making provision for prior knowledge.

3.5.1.4. The integration of the departments

Up to this stage I have argued the case that it is highly improbable to accommodate a cognitive perspective to education within the confines of a traditional system. The philosophy of the staff members militate against any such possibility. Little to no provision is made in a concrete way to correlate the subjects or acknowledge prior learning and naïve theories. So much for the subjects, but what can be said for the integration of the departments? How willing is a chemistry teacher, for example, to relinquish his or her status to become a general educator?

Since the curriculum is 'custom made' to fit snugly into the organization of the institution, so a strong influence is exerted upon the curriculum's organization. The prevailing circumstances at St Sebastian's resulted in a strong compartmentalisation of subjects as was noted in Andy's views on integration. Posner (1992:143) observes that to have strong compartmentalisation of subjects, there needs to be an equally strong departmental structure

within the school. Is there any possibility of narrowing the rifts between the departments at St Sebastian's? There seems to be some divided opinion on the matter.

Mr Robinson, on the one hand, believes that integration of departments is fruitless because of his deficit of knowledge in certain subject areas. He opined that this would compromise his efficiency and deny learners exposure to his expertise in the field of Chemistry. Having completed doctoral research at Cambridge, he was armed with an enormous fund of anecdotes concerning Chemistry in society. For example, he once engaged in a research project involving chlorophyll. He explained how he removed a magnesium atom from a chlorophyll ring and replaced it with a cobalt atom which then behaved in the same way as vitamin B¹² would in a test tube. He reasoned that it would be a disservice to the learners to divert his attention away from Chemistry if he now had to chart the unfamiliar topics of Biology which he had not studied since his, "bean seeds had died in standard 8".

This is only one perspective. Gavin Cook, on the other hand, was more amenable towards the concept of departmental and subject integration at the grade 8 level. In terms of the subject matter Gavin suggested the following:

Gavin: ... perhaps the children here should be doing three subjects only, but in fact eh ... integrated studies, which could involve History, Geography, Science, Mathematics ... the whole 'caboodle', but the biggest factor I would be stressing was language

I then inquired about departmental integration, but he was somewhat evasive. This was the way I phrased my question:

Interviewer: Just to, perhaps, put a little boulder in your way: How would an English teacher feel about having to cope with science classes in a school like St Sebastian's where they have so often seen themselves as exclusively English teachers?

Gavin: Um ... there I don't think there is any great ... eh ... difficulty. After all it's comprehension I'm looking for.

My conclusion from his comments is Gavin has not contemplated the full ramifications of developing an integrated curriculum supported by integrating the departments. Be this as it may, he still sees some leeway for integration, which Mr Robinson completely dismissed.

3.5.2. My own course : A process approach

3.5.2.1. A logical argument for my approach

To understand the course which I designed, the notes of which are to be found in Appendix C, it is imperative to understand that OBE is a means to design, deliver and document the achievements of learners. This caused me endless confusion since the Government Gazette, No 18051 of 6th June 1997, only provides the outcomes, assessment criteria (judgement statements) and range statements (what learners are to exhibit). These outcomes only specify skills and attitudes while paying scant attention to content. In the past, teachers always resorted to a syllabus and accompanying guidelines. However, OBE allows teachers wide latitude to decide upon concepts and their sequencing, the learning activities, the teaching strategies and assessment instruments.

After much deliberation I took a logical guess as to how to proceed and settled upon a process approach. I based my decision upon clues gleaned from reading the information describing the specific outcomes. Specific outcome 1 of the Natural Sciences (Government Gazette 1997:146) states: "Use process skills to investigate phenomena related to the Natural Sciences". Before defining the assessment criteria and range statements, the gazette emphasizes the need for the collection of wide ranging data. A range statement of the senior phase labours the point by stipulating that learners must access a wide array of sources of information on phenomena. Furthermore, learners were expected to use a broad range of instruments or devices to collect, measure, analyse and present data and findings. This I interpreted to mean that learners were expected to make use of bar-graphs, pie-charts and straight line graphs to represent experimental data.

Aside from the process skills in an experimental sense such as observation and hypothesizing which I have already elaborated upon in the thesis, I reduced the requirements of specific outcome 1 to the need for learners to be competent readers.

In hindsight, my decision was not so far off the target. Bray (1998:10) illuminates that one of the functions of a teacher in such a system as OBE is to access and organize resources so that learners will be able to demonstrate their achievement of learning.

Hardly in command of the niceties of OBE, I then specified two programme outcomes in the following way:

- 1) the learners must be able to access information from a variety of sources – be it digital or print – in order to apply that information to the solving of problems of a scientific nature which affect society,
- 2) The learner must be able to demonstrate process skills in conducting scientific investigations to explore phenomena.

I reasoned that the other eight specific outcomes would be made provision for based upon a learner's ability to read and experiment. I assumed (erroneously so) that St Sebastian's had a pupil population of high quality learners. It was a school of some prestige and was located in Buxley; to my mind, the home of the English language in South Africa.

3.5.2.2. The course

Months prior to the start of my fieldwork at St Sebastian's in January 1998, I acquired and read numerous articles from scientific journals. Armed with missionary zeal and yet counterpoised with absolutely no experience in curriculum development, I selected what I considered to be the most appropriate topics in Chemistry and Physics which could be used in a study related to the theme: *The Earth and Beyond* (Government Gazette 1997:144). This was one of four themes used as organizing principles for an OBE curriculum which provided the context to assess learning.

3.5.2.2.1. The structure of the content

The configuration which I used to structure the content was what Posner (1992:129) would describe as “pyramidal” or “hierarchical”. Typical of this structure are multiple unrelated concepts or skills which are studied almost concurrently becoming necessary for learners in order to master subsequent concepts or skills. Posner (1992:130) makes the concept more lucid with the following diagram shown in figure 3.7.

Hierarchical structure of the content

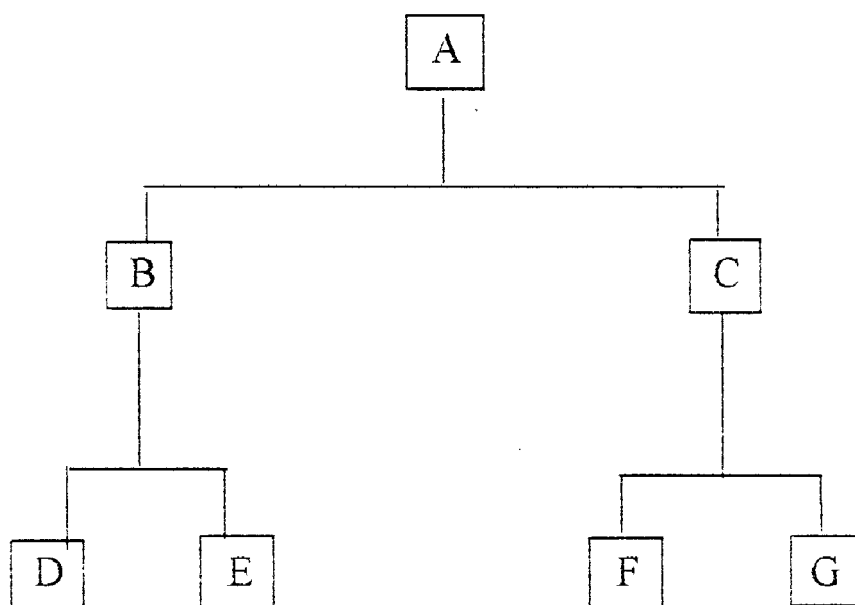


Figure 3.7

Glance through the content arranged in a hierarchical structure which would then give rise to key concepts to explore the theme: Earth and Beyond.

An important consideration was the position of Mathematics in my structure. According to Brandt (1992/3:69), who quotes Spady, Mathematics is an enabling outcome and not an outcome in its own right. Although it has its own structure it must be learnt in ways that link it to real-life problems, issues and challenges and treated as a tool which it was intended to be.

The result of reading the article of Brandt was I decided to incorporate some Maths topics in my Science lessons. Since the analysing of results was going to be important in terms of graphs and pie charts the learners were ultimately going to need the prerequisite concepts of ratio and proportion and equations.

Project Assignments:

- 1) Research the constitution of the solar system
- 2) A study is to be made of the 9 planets, asteroids and comets
- 3) Learners to be able to make an orrery depicting the solar system
- 4) Research the birth of the solar system
- 5) Research formation of earth and distribution of the elements
- 6) Learners to use a star atlas to identify major stars, constellations and nebulae of the southern skies
- 7) A study to be made of earth's size and shape with special mention of rock formation in terms of friction.
- 8) Learners to explain tides with reference to forces exerted by sun and moon
- 9) Study made of moon's gravitation
- 10) Study of pressure with reference to the atmosphere

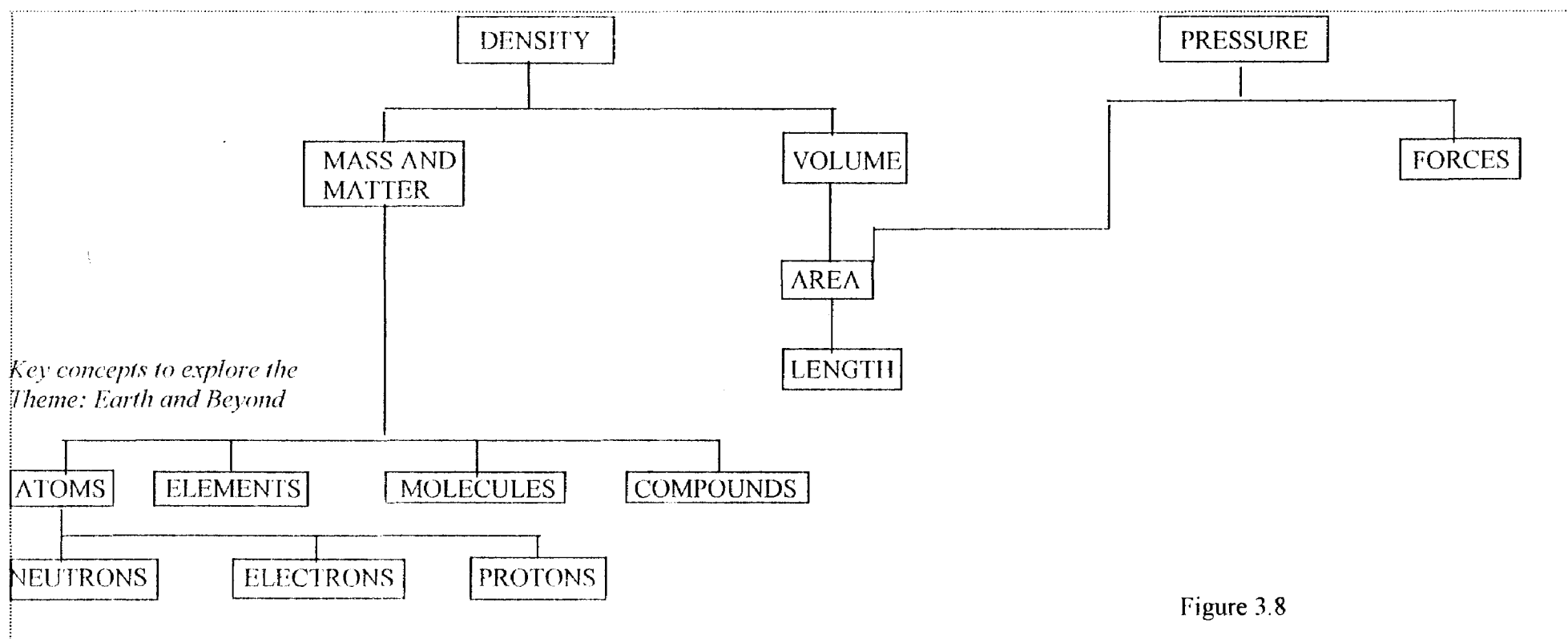


Figure 3.8

Concept map and project assignments planned for course

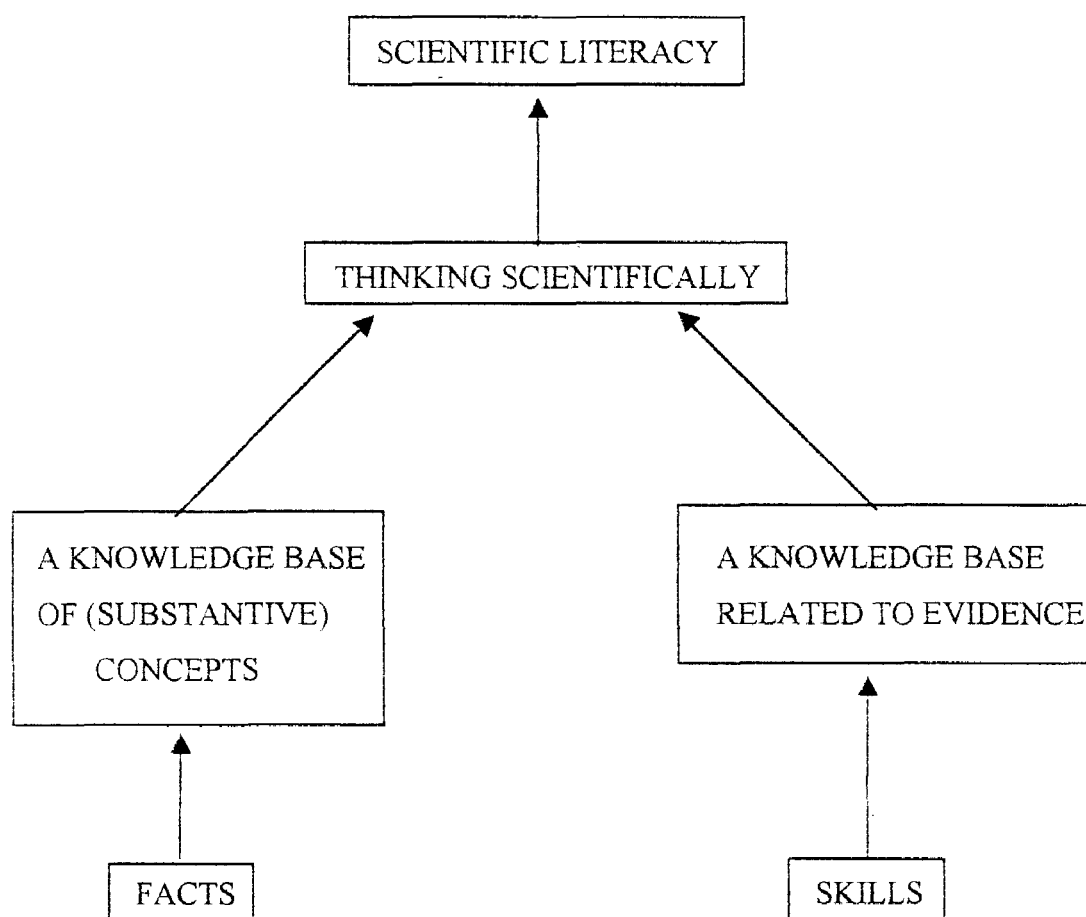
Germinating in my mind at this point were the rudiments of an integrated course. I had weaved elements of Physics, Chemistry, Mathematics and English. The scientific articles which I planned to issue were generally historical in context and so History added a further spice to my *pot pourri*.

In the opening paragraph I alluded to the confusion which resulted in me trying to get a handle on OBE. Apparently this confusion is justified and is quite a normal occurrence. Barnes (1993:5) quotes Murphy (1984) who explains that educators struggle with the concept of OBE and how to implement it because understanding OBE requires a construct of integrated structure, or gestalt. All elements are to be integrated, be it the content, attitudes and values, or the teaching, learning and assessment processes. The focus is on integration. Subjects which were once perceived as being separate entities are to be correlated, shown in figure 3.8. This proved to be a challenge for me, the magnitude of which I did not appreciate before facing a group of rambunctious grade 8 learners. I will now examine my implementation strategy in terms of a model of scientific literacy couched within a framework of social constructivist methodology.

3.5.2.3. Scientific literacy within a social constructivist framework

The reader will recall that my original two programme outcomes stressed the learners' ability to access information in the development of concepts and apply process skills in conducting scientific investigations. This approach is the embodiment of scientific literacy according to Gott & Duggan (1996:793). These authors compiled the following model specifying the components inherent in the concept of scientific literacy. The model is shown in figure 3.9.

When conducting my fieldwork at St Sebastian's I had fanciful notions of striving towards designing a course which would embrace scientific literacy. The teaching strategy to achieve it was to apply social constructivist principles. I will now present some expert opinions on teaching strategy and then describe the events as they unravelled to illustrate the contrast between the theory and the practice. Of particular note is how influential the organization of a traditional institution can be in stifling a preferred methodology.



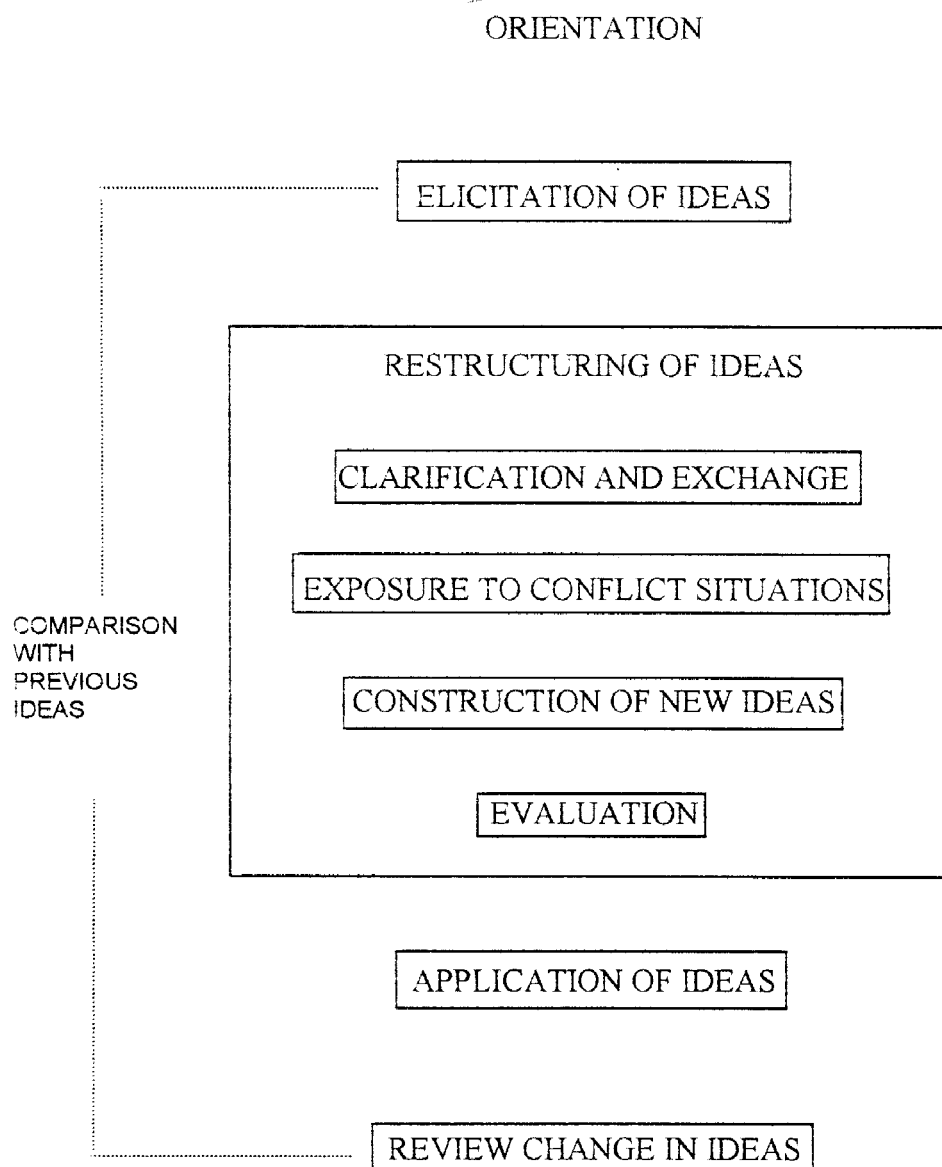
Gott & Duggan (*ibid*)

Figure 3.9
A model of scientific literacy

3.5.2.4. Constructivist teaching methodology

Appleton (1997:303) identifies the key tenet of constructivist-theory which suggests that learners use existing ideas to make sense of new experiences and new information. To promote learning, there is to be a change in the learner's existing ideas, either by adding some new information or by reorganizing what is already known.

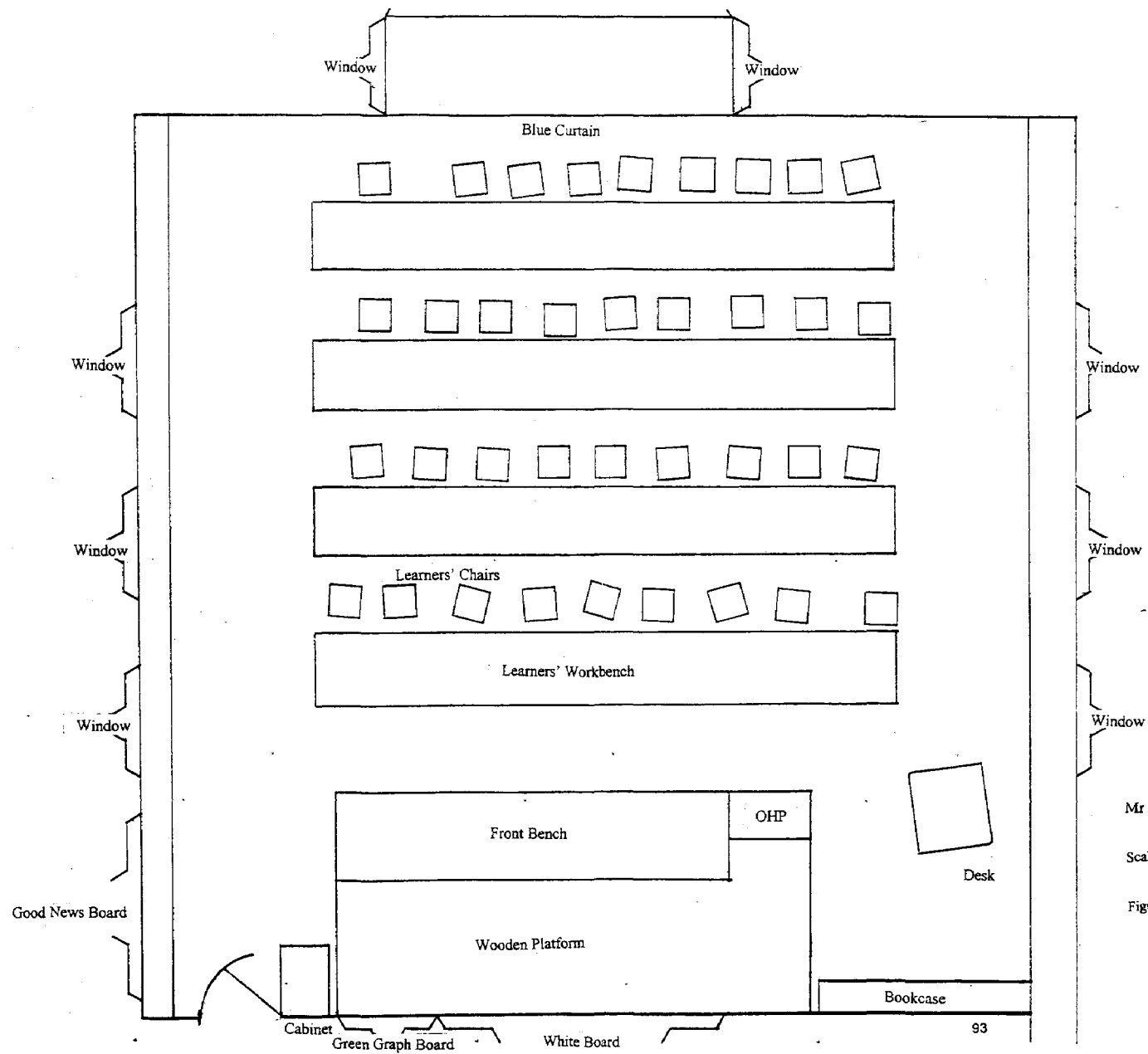
Driver (1988:141) represented a constructivist teaching sequence shown in Figure 3.10.



Driver (1988:141)

Figure 3.10
The constructivist teaching methodology

Driver (1988:142) explained that after capturing the interests of the learners in an *orientation* activity, the learners discuss and review their own ideas or models. This is the *elicitation* phase. In keeping with Appleton's commentary, prior ideas are identified. Driver (*ibid*) recommends that these ideas be displayed on posters which may be amended as the learning process continues. Both learner and teacher need to be informed about the prior knowledge



Mr ROBINSON'S CLASSROOM

Scale 1m = 2,5 mm

Figure 3.11

of the learners. Thereafter, a *restructuring* phase commences. This is where the learners are exposed to situations such as experiments or what is found in the literature which is arranged by the teacher. The mission is to expose the learners, with their current cognitive structures, to a situation which cannot account for what is observed or noted. Confusion and dissatisfaction arises in the mind of the learner and thereafter follows the construction of new ideas. Throughout the process there is an emphasis upon negotiation between learners as they trade ideas to explain the discrepant events. Eventually, if the restructuring process is successful, accommodation results. This is not the end of the sequence for the teacher then needs to engineer situations where the learners will *apply* their revised conceptions in a range of ways. This may involve practical construction tasks, experiments, imaginative writing tasks or more conventional text book problems to solve. At the end of the lesson sequence, learners then compile new posters to compare with the previous ones to review how change has occurred. [emphases are Driver's].

The reader will remember in chapter 1, I referred to mastery learning as an integral part of OBE. This method of correctives and feedback can easily be assimilated into the constructivist methodology. If the restructuring and application phases are not successful, and it is so detected, then remediation may follow before continuing. This is one of the chief reasons, to my mind, why social constructivist theory is compatible with OBE principles. I now turn my attention to events in the field.

3.5.3. The classroom environment, the course, the learner response and the issues that were raised

Before any discussion of the course and the learner response to it can be set in motion, I consider it essential to describe the laboratory which was, for the most part, the site of learning.

3.5.3.1. The site of learning : Mr Robinson's laboratory

From the scale drawing alongside in figure 3.11 it becomes obvious that the site of learning is a traditional laboratory with furniture consisting mainly of permanent fixtures.

When facing the board, learners would immediately see a computer with a bookcase behind it laden with several shelves of books. The side benches were generally stacked with piles of notes waiting to be issued. This is the first trace of the nature of the institution – learners

were being geared towards exam training. Further evidence of this purpose is to be found on a green chalk board on the front right hand side of the classroom near the door. The board was entitled “The Good News Board” and listed Mr Robinson’s test dates scheduled for the various classes. In keeping with this theme, what becomes vital in an exam is time. On the right hand side of the classroom was a clock and the note next to it read: “Time will pass ... but will you?”

When compiling these field notes, I wondered what impression learners gained from such a classroom atmosphere. Immediately, I conjectured, just from these stimuli which I mentioned, learners must receive the impression that they are expected to sit quietly in their seats, imbibing the wisdom of the teacher which was as fixed as the benches on the floor. The knowledge which is considered important is contained in teacher’s notes, while deadlines for returning that knowledge are clearly indicated by the “Good News Board” and none too subtly betrayed by the clock on the wall.

The point I am making is the static environment which had been fashioned by 150 years of tradition now collided with my competing philosophy of social constructivism. I initially had high ambitions of creating a situation wherein learners would be able to engage in multifarious activities, such as experimenting, researching, debating and thinking creatively about solving novel problems. How disappointed I was to become; I was guilty of setting my expectations too high.

3.5.3.2. The course : A discussion

Notes detailing the course are located in Appendix C. The first section consisted of six units, namely

UNIT 1	Science and Scientists
UNIT 2	Is Science good or bad for society?
UNIT 3	The Scientific method
UNIT 4	Measurement
UNIT 5	Equations
UNIT 6	Ratio & Proportion

My approach was first to contextualise Science in our society. I thought the best way to accomplish this was to present the learners with hand-outs containing readings which were to become sources of discussion and debate. After learners had adjusted, they would then be expected to go further afield in search of their own literature in the library. My thinking was ultimately to reach a stage where learners would demonstrate their ability as independent researchers. For the time being, I was content to give them readings from journals which I considered appropriate.

After reading through the first unit, *Science & Scientists*, the reader will note that I asked them for a drawing of a scientist in action and a note on what Science entails. Once complete, learners were expected to read the extracts and, much like a comprehension, answer the corresponding questions.

Appendix D shows some of the efforts which I received. Bear in mind that I was interested in a learner's prior knowledge and this assignment seemed fair enough.

The reader will notice from the contributions that the learners perceived Science to involve scientists doing experiments. Either in words or pictorially the data exposes the thoughts of 12-year old learners: "Let's do experiments!" Yet, as committed as I was to social constructivism, I chose to ignore the learners prior expectations to my peril. My agenda was to emphasize reading and research, but as you have seen, the learners had other expectations and were generally weak in the area of language composition. Through inexperience I then issued the second unit: *"Is Science good or bad for society?"*

To give the learner a balanced view, I presented the negative side of Science and Technology in "Tribal Warfare", an article which had its origins in a Scientific American journal. The other entitled: "Taxes and Triangles" presented a positive view of the ancient Egyptians using Mathematics to their advantage in building their pyramids. Accompanying each reading were questions and activities which the learners were expected to perform in groups. You will notice the integrated nature of the assignment which was flavoured with elements of English, Mathematics and History, while referring to Science and Technology.

Even in these early stages I was beginning to sense some inertia on the part of the learners. When asked the following session for the submissions of assignment 2, no one complied. Learners protested that it was too difficult or did not have enough time for the homework because of other commitments. Mr Robinson, himself, showed signs of discomfort during these early stages and raised his concerns that my course was devoid of practical work. I chose not to heed his warnings and asked if more time could not be made available to do practical work and research after hours. I began to realise that because my assignments were fairly difficult, 43 minute periods were not sufficient. The following day Mr Robinson returned with the message from the administration that no extra time for Science could be spared. The grade 8s were only allowed three 43-minute periods per cycle. He did concede that learners may be available for excursions on occasions called RAP (report and project) days.

A RAP day was scheduled once in a blue moon and, as I comprehended it, was utilised for projects on the part of learners while teachers completed report cards. On one such RAP day, I arranged with the JLB Smith Institute of Ichthyology to present a lecture-cum-demonstration session on scientists and what they do. This was to become the one and only excursion which was permitted because of the pressure programme of the learners.

Not deterred by the negative feedback from the class or Mr Robinson, I soldiered on changing strategy from English comprehension assignments to Mathematical ones. I deemed it necessary to study equations and ratio and proportion as this will be invaluable to learners in drawing graphs and representing information using pie-charts. The lessons which I hosted were all teacher controlled. After a couple of weeks at St Sebastian's, I was so constrained by the limitations of time that I completely abandoned constructivist teaching methods in its purest form. The learners were struggling with the concept of equations and algebra as the evidence of Appendix E portrays. Yet, regardless of the need to assist slower learners with remediation, I pressed on lesson after lesson, trying always to keep pace with the bell.

Before leaving for an Advanced Research Methods course at Rhodes University for a fortnight I asked Mr Robinson to "facilitate" a lesson on "the scientific method" which is Unit 3 in Appendix C. The notes were carefully prepared, but I made the mistake of using difficult jargon such as dependent and independent variables. Nevertheless, after the two week period, I, unbeknown to Mr Robinson, visited his laboratory and discovered that the

notes had not been issued and the lesson must have been taught according to a traditional demonstration/discussion style.

During a telephone conversation with Mr Robinson, he informed me that after his interaction with the class he had the 'gut feeling' that the learners were finding my lessons rather dull. He suggested that I would need to, "draw them in more". Although difficult to accept at the time, after careful analysis, I understood the significance of his statement. It boiled down to an interpretation of roles – the roles of the learner and the teacher. I reasoned that learners must become responsible and active in the learning process, while teachers no longer occupy the limelight. Mr Robinson and the learners were still responding to the dictates of a traditional system, while I was struggling to operate in a way which demanded more time to begin with. In other words, we were on completely different wave-lengths and did not understand each other. St Sebastian's never understood OBE and I never understood the constraints of the existing organization.

In addition to the "Scientific method lesson" which Mr Robinson organized, I asked him to allow the learners to visit the library to research how Science had influenced their culture. The purpose was to gather information and report back to class the following week and write a criterion referenced test. This is test 1 in Appendix C. In appendix F is a sample of contributions which I received. They were disappointing in that they lacked flare but what was even more disheartening was Mr Robinson's feedback to the effect that learners had squandered valuable time in the library. Obviously, the learners were not accustomed to such activities as independent research and the work produced certainly confirms their lack of enthusiasm.

Immediately after I had returned from the methods course to resume my field work, a parents' morning was scheduled for grade 8. Enthusiastically, I tried to gain access to the meeting with tape recorder and field notes, but was denied this by authorisation of the headmaster. It was probably just as well because Mr Robinson had to weather some scathing criticism from one of the belligerent mothers. She did not appreciate the fact that her son was a guinea pig in some educational experiment which I was developing. Later that morning my supervisor, Mr Robinson and myself had a meeting where a letter signed by the headmaster and Andy Christianson was presented. Examine its contents in Appendix G. The reader will notice that I was being held fully accountable for the failings of the course while St

Sebastian's was credited for encouraging new ideas which may be to the benefit of the learners.

This was an extremely embarrassing experience since what I had attempted had failed. To add salt to the wounds, my failure had now been disseminated among the parents and staff of a high profile school. As desperate as my situation had become, I had only one recourse – to admit my mistakes. I had set my ideals too high, while not being cognizant of the learners' developmental stage.

Burns (1986:92) refers to Inhelder & Piaget (1958) who remind one that learners between six and twelve are in a concrete operational mode of thinking. They can only discuss the world as it is. This is why experiments and practicals were so important in the repertoire of Mr Robinson. Unfortunately, I ignored his warning and disregarded the growing hostility and written evidence from the learners. They obviously were not coping with the passages I had prepared or with the algebra which embraced new mathematical concepts. It was time for a new strategy.

3.5.3.3. The new strategy : A practical approach

The new strategy was to focus on science practical work. I developed a practical entitled: "Density and the processes of Science". This practical was scheduled for a 43-minute period. Thereafter, followed a consolidation period where I taught them the process skill of tabulating results and plotting points in a cartesian plane. By way of discussion, I attempted a restructuring session wherein learners could develop the concept of the inverse relationship between mass and volume and how this influences density. For example, the greater the mass, the smaller the volume then the greater the density.

For the purpose of my argument I have presented the reader with a transcript of teacher-pupil interaction which occurred at the end of the consolidation period and the beginning of the period which followed. In this lesson I wished to establish how successful the restructuring process had been and learners, through a teacher demonstration, were asked to explain the "ball and ring" experiment in terms of density. Particular points of interest which arose out of this selection of data are:

- (i) the expectation of the need for strict control by teacher and pupil,

- (ii) limitations of time in the school structure to do academic work, and
- (iii) St Sebastian's as a mark oriented institution.

What follows is teacher-learner interaction at the end of the period after the consolidation period on the 3rd March 1998.

Teacher: Now, I'm going to ask, on Monday, for the experiment write-up on Monday – marks, for the end of this term. There is another mark order coming up in a month. I am going to ask for the experiment write-up.

On Monday. I'll see you again on Monday. I'll ask for that experiment write-up ... so be warned. I will be giving you an assessment mark for that.

Learner: Our table Sir. Must we have the table and then write up why some things "sink and float?"

The next period was scheduled on the 9th March 1998 and began in the following way:

Teacher: Put that cricket ball away. Settle down and let's take out our notes. Today, I want to take in your practicals.

Learner 2: Ah! Please Sir! You can't Sir! Ah!

Teacher: Also your science files as well. I want to see how you have arranged things ...

Learner 3: Sir! Sir! [much remonstrance because learners did not do their work or maintain good notes].

Learner 2: Please Sir. Can't you give us more time! You said you would!

Teacher: Alright ... The rest of you ... I want you seated so we can get on with our lesson. Yes?

Position of activity in laboratory for the practical demonstration

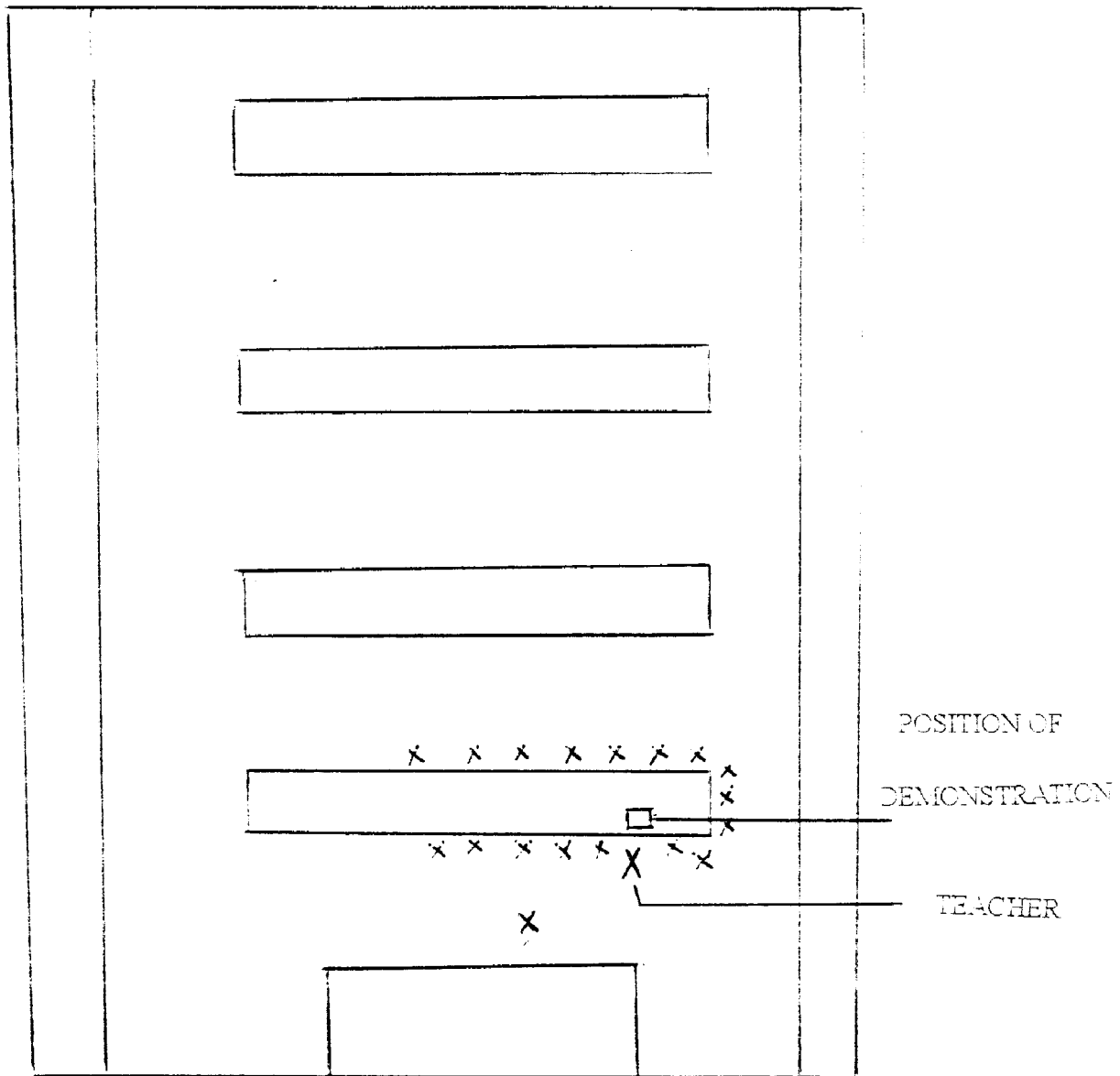


Figure 3.12

Once settled, I called the learners to the front for a teacher demonstration of the Ball-and-Ring experiment. The following diagram of the classroom indicates the position of the demonstration and the close aggregation of learners, shown in figure 3.12.

The teacher-pupil interaction continued as follows:

Teacher: Grade 8s! Our focus was that of?

Learner 1: Density, Sir. Water.

Teacher: Now, what I've got here is a piece of apparatus called ...?

Learner 2: A brass ball, Sir.

Teacher: A ball and ring. The ball and ring experiment usually used in the context of heat, but we are going to use it in the context of ...

Learner 1: Water.

Teacher: Density. Now, this ball has a certain ...?

Learner 4: Weight.

Learner 3: Mass!

Teacher: Mass. Let's not use weight ... mass. Just remind us – what does it mean?

Learner 5: The amount of content ... The amount of mass ...

Teacher: It is the contents of the solid in terms of matter it contains. Now, it also has something else. You mentioned it, Roland.

Learner 6: It's going to change.

Teacher: No, it got mass and ...

Learner 7: Volume.

Teacher: It's got mass and it's got volume ... Right. OK. Let me see what happens. Be quiet please, when I put the ball through the ring.

Learner 2: It goes through!

Learner 4: It won't work, Sir, when you heat it up.

Learner 8: It won't work, because the chain goes around.

Teacher: [Holding ball in flame].

Learner 7: How long do you have to hold it there Sir?

Teacher: Now, what is happening to the ball at the moment?

Learner 5: It's expanding.

Learner 8: Getting bigger!

Learner 10: Enlarging!

Teacher: OK. What can be said for its volume? What can be said for its volume?

Learner 9: It's increasing.

Teacher: Its volume is becoming greater and its mass is staying the same. Now in terms of density, what can be said for the ball? Its density at the start compared with what it became.

Learner 11: The density is the same.

Teacher: He says the density is the same. Any advances on that?

Learner 2: Density is the same.

Teacher: Density is the same. Alright ...

Learner 5: It must be the same because the mass remains the same.

Teacher: OK. We'll come back to that. Now this experiment over here is the reverse of

Learner 12: Will the ball fit through the hole? ...

Teacher: Here we are going to do the reverse.

Learner 10: You are going to heat the ring, Sir.

Teacher: [Heating the ring]. The ball won't go through the ring. It has too much? ...

Learner 8: Mass!

Teacher: NO.

Learner 7: Volume.

Teacher: Too much volume. Right. Too much volume.

Learner 7: You'll have to heat this.

Teacher: Is that the only way?

Learner 4: You could freeze the ball. Hi! Hi! Hi!

Teacher: Just heat the ring.

Learners: [Talking, laughing and joking].

Teacher: OK. Heat the ring.

Learner 7: Expand it.

Teacher: Let's expand it.

Learner 1: It just went through oaks.

Learners: Wooh ... wooh! Yippee ... [clapping and applauding].

Teacher: Shut-up! In terms of what we have seen here – explain the experiment in terms of density. What happened to the density of this?

Learner 4: It becomes greater.

Teacher: So you need a larger ring [Learners laugh: Hi! Hi! Hi!] In terms of density. What is your explanation.

Learner 11: The density stays the same..

Teacher: You say the density stays the same ...

Learner 9: Volume changes, density stays the same. [Whole cacophony of voices. Everyone offering answers simultaneously].

Learner 2: Didn't we have to hand in our project for today!

Teacher: We are going to talk about that Grade 8Z. Let's go back to your places [Learners return to their seats].

In light of this transcript I will examine the emerging issues more closely.

3.5.3.3.1. The issue of control

The first issue of interest is the mutual expectation in the classroom by both teacher and pupil of strict control. Davis *et al* (1993:631) explain that this is a key feature of the traditional objectivist paradigm where it is believed that a child attains personal control only through voluntary submission to discipline imposed and rewarded by an outside authority. From a constructivist point of view, Davis *et al* (1993:631) contrast this with the idea of valuing individual differences and interests of students. The teacher is no longer a controller but a classroom manager. In seeking to establish a healthy interactive climate, constructivists need to adopt cognitive and humanist psychologies. In such conditions, learners have choices and concomitant responsibilities which benefits their education and empowers them to become well rounded citizens.

You will recall that I struggled to maintain order in the classroom. I even admonished them with the command: "Shut up!" This emphasizes the point that the expectations of the school and its hidden assumptions exert enormous influence on classroom relations. Even with the best constructivist intentions I still resorted to the traditional methods of tight control.

To cement the notion of mutual teacher and learner expectations of control consider the views of Cecil Butcher, another science teacher in the school.

Cecil: They have just got to know you and eh ... what ... um ... and I have never been one to say sit down and don't open your mouths. Shut up! I want two-way communication, but they must know that when I open my mouth they belt up, and I am not prepared to have them sitting and chatting if I am chatting. You know, you establish formal ground to start with.

Compare Cecil's opinion on discipline with a grade 8Z learner's views on my lessons:

Learners: The class itself, kind of puts a lot of people off ... not off, turns some people on ... some people off, because, I mean, some people sit at the back. They, they can talk without other people hearing them and then they mess around and you know there is copying of work that goes on.

Reading between the lines, I perceive that he would prefer a more controlled class. Yet, teacher control need not necessarily be as overt as this. I once observed an English teacher's response to learners when they were reading a difficult passage of prose. Periodically, learners would ask her the meaning of a word such as 'medium' or 'clairvoyance'. She never insisted that they become self-reliant and use a dictionary, but yielded and defined the words. Hence, they remained dependent upon her and she subtly controlled them.

3.5.3.3.2. Limitations of time

The second issue of interest is the limitations of time which learners have to concentrate upon academic work and specifically reading. The programme in figure 3.13 shows an average day in the life of a St Sebastian's school boy.

You will notice that boys were literally begging me to extend the time to hand in their assignments. One even said he did not have the time. From my questionnaire data I discovered the reason for his request. Learners are heavily burdened with sporting and cultural commitments. The following two bar graphs in figure 3.14 compare the amount of time spent playing sport and engaging in cultural activities versus the time spent reading. One learner does 17 hours per week of the former and can only manage 2 minutes of the latter. I am not surprised that their writing ability is so poor.

One Wednesday afternoon I walked around the school playing fields with my camera and the picture 3.27 alongside confirms how the learners spend their afternoons. What is quite distressing is I visited the library and acquired statistics as to how many books were taken out in the first three months of 1998. These were the results in table 3.1.

Daily programme of a grade 8 Learner

Time	Activity and Event
5.45am	Rising bell for grade 8s Cold shower
6:15am	"pick ups"
6:25am	Bell for grade 9s-grade 12s
6:30 am	Grade 8s go and fag (duties for senior boys)
7:20 am	Roll-call
7:25 am	Bell, depart for school
1:00 pm	School ends and lunch then rest period
2:00 pm	Bell and classes Change for sports
4:50 pm	Return to house and shower Quiet time Societies
6:30 pm	Supper
7:25 pm	Roll-call
7:30pm – 9:00 pm	Prep (homework)
9:00 pm	Prayers
9:00 pm – 9:30 pm	Free time Lights out

Figure 3.13

Corresponding hours spent by learners in extra-mural activities vs pleasure reading

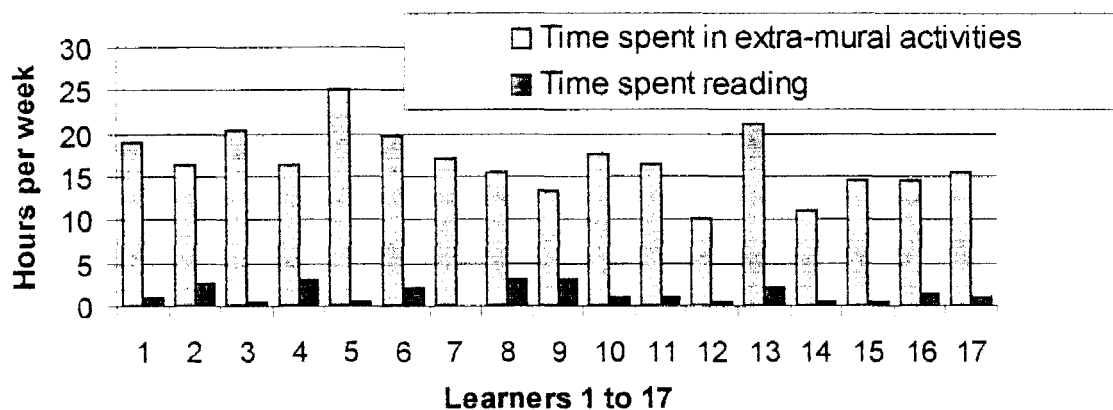


Figure 3.14

CLASS	TOTAL NO. OF BOOKS TAKEN OUT
Grade 8	227
9	166
10	156
11	98
12	30

Table 3.1

Number of books taken out in 1st term of 1998 by grade level.

Note the marked decrease in the number of books taken out from grade 8 to grade 12. These figures, although accurate, are deceiving because the learners, when they have access to the library, mainly utilise it to consult the CD ROM or newspapers and magazines. Yet, surely, the statistics do indicate that the learners are deprived of opportunity to do some pleasure reading.

This is the viewpoint of Gavin Cook who forwards the following concerns relevant to the matter and how sport absorbs most of a child's time and energy.

Gavin: Now you are talking, with due respect, to an ex-sportsman and I will take on anybody as far as achievements in sports go on this staff and knock the hell out of them ...

But ... ja ... ja ... I have been a sports fanatic. I love my sport, but I think that it is over-emphasized. But that is the South African public – especially schools not good at sport – the children don't come.

Earlier I recall he mentioned how necessary it was for learners to do pleasure reading and that sport dilutes this precious commodity of time.



3.27 Learners engaging in supervised cricket on an afternoon

3.5.3.3.3. Importance of results

The reason learners were so anxious to extend their time is they had a strong desire to do well. They equated more time with more opportunity to perform the tasks. So, where does this desire stem from? The answer is supplied by Cecil Butcher:

Cecil: They [the learners] are very results-orientated ... That's where it comes from, their families ... Normally, the parents are fairly ambitious and they are very results-orientated. They are paying a fair amount of money for their sons to be here and I suppose they do put a fair amount of pressure on the kids to do well.

To illustrate how damaging this continual striving for marks can be, ponder the words of the following grade 8 learner.

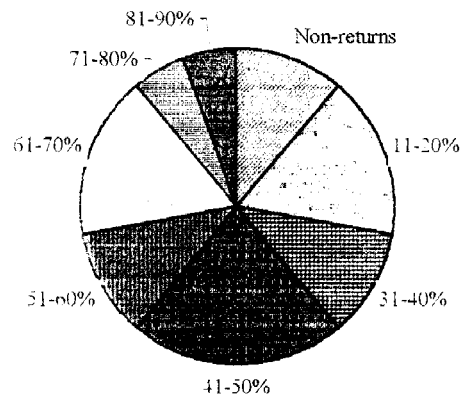
Learner: To me, it's kind of like that it's always been like that, to me. When I bowl an over in cricket, I don't, you know. It is not supposed to be this way, but when I bowl I keep on worrying about what the figures [the marks] are going to look like on the book.

3.5.3.3.4. Formative and summative assessment and the expectations for assessment at St Sebastian's

The issue of formative and summative assessment at St Sebastian's proved to be very confusing. Learners were so accustomed to the finality of an end-point test that even when asked to re-submit an assignment, I hardly received any returns. The staff, too, were also not familiar with the concept of developmental assessment. Mr Robinson and Gavin Cook, when encountering the term in my questionnaire, drew a blank and asked for an explanation.

As far as learner expectations of assessment are concerned, learners were far more comfortable with the product oriented test in the second mark order than the process oriented test featuring in the first mark order. I presume, the second test on density required lower order skills of simple recall and algorithmic methods whereas the first demanded analysis and research. A comparison of the results of the two tests are presented in the pie-charts below in figure 3.15.

TEST 1 Results of process-oriented test



TEST 2 Results of product-oriented test

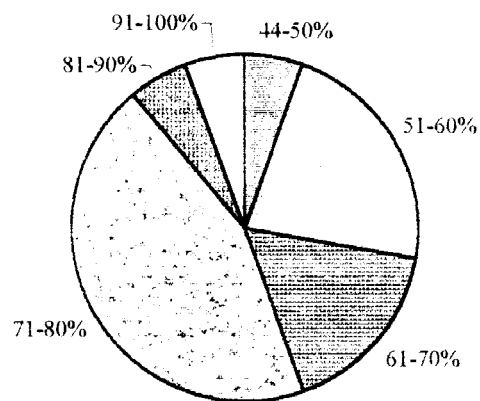


Figure 3.15

As a final confession though, I was not entirely truthful in the children's mark orders. Their results were destitute of any validity or reliability. Boys who had hardly written two sensible words the whole term received upwards of 45%. This was to comply with Mr Robinson's insistence that the results of my class be comparable with his.

From an OBE frame of reference, marks are not important. Ultimately, the emphasis is on whether or not the learner can accomplish the task proficiently in practice. In certain cases marks can be terribly superficial and arbitrary. At St Sebastian's, learners receive an impression mark between 1 and 7; 4 is competent; 3 or lower corresponds to poor work, 5 or higher corresponds to good work. At the end of the mark order I happened to be typing in impression marks on Mr Robinson's computer and he had just returned from tea, quite incensed that the administration should demand that all learners receive impression marks between 4 and 7 inclusive. The inference being that teachers were not allowed to judge a boy incompetent or slothful, even if it was the case.

3.5.4. Conclusion

In conclusion to this case study I would like to quote the profound words of a grade 8 learner who let his feelings be known concerning my course.

I know this is a new thing, that you have to do but it sucks and to me is not Science. I know of three guys that whatted (sic) to go to Mr Butler and I have talk them to just stop and give it a chance (sic) but now I can't (sic) take it Sir, it is so unfare (sic) that you take off marks because of our spelling and grammer (sic) and I don't see the point of doing maths that we have already done on (sic) the standerd (sic) five year.

Granted I omitted to compile a careful situational analysis of the culture and organizational factors impacting upon the St Sebastian's curriculum recommended by Carl (1995:47). Egregious blunders were made in my estimates of the learners developmental levels and capabilities. However, as disappointed as I often was in doing this field work, I learnt that it is not possible to entertain two fundamentally different philosophies under the same umbrella. If OBE is to be introduced into a school with its hallmarks of an integrated curriculum, flexible scheduling and authentic performance assessment then it needs more

than piece-meal attention. It requires a total systems re-alignment. There can be no compromise in this regard.

As far as my research is concerned I have found consolation in knowing that accurate data was collected even in the face of harsh censure, criticism and abuse.

Chapter 4 : The Mtunzini Case Study

4.1. Introduction

In this case study I first consider the site of my research, namely, Mtunzini High School. Then I present some of my assumptions, apprehensions and concerns when starting my field work. What follows are three vignettes to provide the reader with insights into the teaching environment which I was entering and which exerted such a strong influence upon the learner. Thereafter, I presented some research relating to several issues surrounding the key systemic factors of time scheduling, disruption brought about by unforeseen events, integrated curricula, resources and assessment. Once completed, I begin with a description of my own course where I explain the problems which I experienced and the passage I chose to alleviate the impasse. A vignette describing my use of practical demonstrations concludes the case study and raises the issue of whether science teachers can successfully circumvent the ubiquitous problem of resource shortages.

Mtunzini High School : Description of the school milieu

Mtunzini High School is rated as a middle class African school. The first impression gained is that of plain brick and mortar buildings (photographs 4.1) which contrast sharply with the shack dwellings on its periphery (photograph 4.2).

Nearby, one can see a football field (photograph 4.3), or the skeleton of one, which is poorly maintained and overrun with weeds, litter and stones. For the six weeks duration of my field work I never saw anyone utilise the football field since the children preferred to play their games on the more even basket ball courts behind the school.

Although the school is located in a high density area of Duma, Buxley, one cannot help but notice the rustic presence of African culture which encroaches upon the boundaries of the school. Periodically, herds of goats and cows will be seen wandering past the school, attended to by shepherd boys. It is not uncommon for a goat to graze on the coarse grass within the school perimeter. No one seems to mind; farm animals are an essential part of African culture and tradition.

4.1



Mtunzini High School
(the administration block)

4.2



Shack dwellings on
periphery of school

4.3



Unused football field

4.2. The school facilities; qualifications of teachers; school mission and fees

4.2.1. The facilities

Mtunzini is a co-ed school comprising some 1200 high school pupils ranging from grades 8 to 12. The classrooms are generally small in relation to the large number of scholars who frequent them. Within the phalanx of school buildings is a series of quadrangles. Within the school itself, learners have few comforts such as tuckshops or common rooms where they may aggregate, relax and enjoy such indoor activities as pool or table tennis. During break time, learners are all compelled to leave the classrooms and go and play their games outside, or have their luncheon packs with their friends.

Notwithstanding these deficiencies, Mtunzini is not short of the basic essential facilities such as a home economics room, woodwork and art centres and an all important library. As far as Science Education is concerned, Mtunzini has two reasonably well equipped science laboratories with provision made for cupboards and adjoining storerooms to stock some basic physics equipment and chemicals. However, nothing elaborate exists such as expensive fume cupboards, gas cylinders or vacuum pumps.

4.2.2. The qualifications of the teachers

Considering that Mtunzini fell under the jurisdiction of a disadvantaged Black Education system during the years of Apartheid, the teachers are relatively highly qualified. As shown in the pie-chart in figure 4.1, teachers' qualifications range along a continuum from standard teacher diplomas (equivalent to a matric and 3 years tertiary level experience) to Masters' degrees.

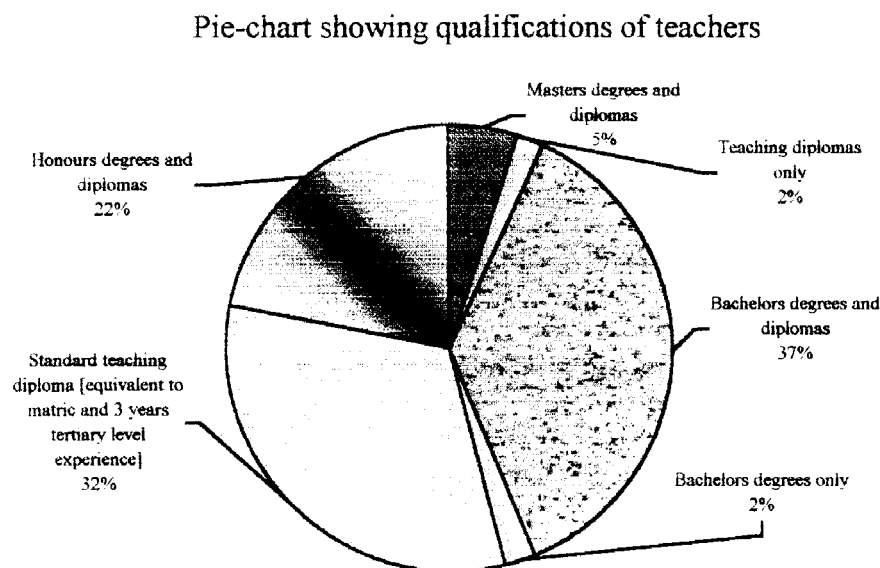


Figure 4.1

4.2.3. The mission of the school

Since the mission of the school is to prepare learners for matric exams, much teaching time and energy is directed towards this purpose. Mtunzini can be proud of their 1997 matriculation results where 84,6% of learners received a school leaving certificate and a further 13,1%, a matric exemption. It is not surprising that the school is dubbed the 'pride of Joza!'

4.2.4. The school fees

In recognition of the learners' often depressed living circumstances outside of school, the learners' parents are obligated to contribute a paltry R40,00 per annum towards their school fees and a further R10,00 should their sons or daughters opt for woodwork or art classes.

In summary, although far from being the poorest of the poor, Mtunzini is a forbidding environment in comparison with traditional white middle class schools. The scars of Apartheid have not quite healed as the ghost writing, "Down with white teachers", shown in photograph 4.4, reveals. Apparently, two years before a radical youth group of AZAPO, who were a small minority and rallied by a few demagogues, protested against the presence of white teachers. Their protest actions were quelled, however, by a group of Black parents visiting the school. This writing on the wall was literally the only tangible shred of evidence to betray the political struggle which dominated past events in the school. Generally, I was welcomed, especially by the learners who would sometimes be seen running from 100 metres away to open the closed gates at the entrance of the school.

Fieldwork at Mtunzini High School and results of my investigations

4.3. Assumptions, apprehensions and concerns

At the start of my fieldwork I was given the challenge of teaching an electricity section to a group of grade 8 learners according to OBE principles. This brief was rather vague, but I approached the task with circumspection in light of my recent experiences at St Sebastian's. The reasons for my hesitance in planning a suitable course were threefold:



4.4 Grafito on wall denouncing white teachers

- (i) The expectations of the learner.
- (ii) Cultural and language considerations.
- (iii) The expectations of the teacher.

I will visit each of these reasons in turn.

4.3.1. The expectations of the learner

As I discovered at St Sebastian's, the student plays a vital role in the enactive part of the curriculum. The expectations can make or break a curriculum innovation effort. Since OBE became widely publicised from mid-1997 it has had its detractors, for example, Jansen's paper [no details known] who levels ten poignant criticisms at OBE. Learners are not oblivious to such disparaging views since it directly influences their academic aspirations. Peruse an excerpt from a student newspaper at the school written by Tando Sandi (1998:8):

Many of the scholars believe that this new form of education will create the (sic) higher failing rate, because we are (sic) busy with our own problems and activities ...

Sandi and his peers had developed the misconception that teachers are effectively sidelined in their education and they as scholars will be left to their own devices to become "knowledgeable".

Sandi's fears are by no means isolated. This syndrome of the traditional student is widely reported in the literature. Loughran & Derry (1997:935) quote Gardner (1991) who identifies most students as being guilty of developing meta-cognitive skills of asking themselves: "How much work do I really need to understand to satisfy the requirements of this course?" This quote is universal and speaks of learners who are reluctant to extend themselves and so resistance is inevitable.

Since my fieldwork experience was of such short duration, I decided it was more prudent to say very little about my mission at the school because of all the "baggage" associated with OBE. Rogers & Dana (1995:523), on the other hand, are opposed to this practice, referring to it as deceitful since if you believe OBE is good for the child then refrain from concealing the fact.

4.3.2. Cultural and language considerations

Jegede (1997:1) informs the reader that: "For the developing countries of Africa dominated and governed by non-western socio-cultural factors, western science means an imposition of one culture over another. It means the replacement of the anthropomorphic worldview with a mechanistic one." Jegede (1997:9) continues with the warning that the difference in world views becomes intolerable for teachers of western background who have to teach students of non-western origins.

Concerning myself at Mtunzini, I knew very little about African culture in relation to western philosophy. For example, I would be hard pressed to integrate traditional African religion and cosmology with the practical matters of electricity. Biko (1978), as quoted in Lubisi *et al* (1997:136), speaks of the importance of traditional music in that African songs were not meant for individuals, but for groups. For this reason, I planned group work activities as far as resources would allow; a practice which dove-tailed with OBE methodology.

Another issue was that the learners were all Xhosa speaking and of limited English proficiency. Therefore, I assumed that my speech would have to be slow and simplified a policy which extended to the notes I compiled on the board or in handouts.

4.3.3. The expectations of the teacher

Although teachers at Mtunzini would prefer to distance themselves from any association with the philosophy of Christian National Education (CNE) and its accompanying teaching theory of fundamental pedagogics, I assumed that the teachers were unconsciously subject to the subtle influences of a rigid behaviouristic paradigm. These teachers may have objected to certain forms of institutionalised racism characteristic of education during the Apartheid years, but it is my opinion that the underlying teaching practice of these teachers is consistent with the philosophy of CNE.

To give the reader an example: I assumed that the teachers would regard themselves as occupying a superior position to their learners since they are authoritative reservoirs of knowledge as opposed to the learners who are passive recipients. This belief is in keeping with the theory of some CNE exponents such as Viljoen, as quoted in Beard *et al* (1981:12) who regards the child as a thing (a non-human). Other authors such as Oberholzer, quoted in Beard *et al* (1981:12), grant the child some humanity but still view the child in a negative

light. The inference here is that teachers would be very reluctant to allow their learners responsibility and so oppose a key principle of an outcomes-based system.

Since CNE has a belief in Calvinism and Science, there is inevitably a preoccupation with measurement through examinations. Anderson (1973) made the widely reported statement that examinations are 'the tail that wags the educational dog' and Chari (1973) reports that educators teach what is tested rather than testing what is taught, as quoted in Dore (1976:162). Orevbu (1984:223) provides an African perspective claiming that African schools tend to, "Teach too many things too fast ... perpetuated by the requirement that all official examinations be based on these." This is an apposite quote relating directly to Mtunzini. Learners, as they are approaching examinations, are continually drilled by their teachers to meet the demands. At a later stage in the thesis I have presented a series of vignettes revealing the circumstances prevailing in the school. More importantly, teachers define their roles, not so much as educating learners, but in preparing them for examinations and tests. It is my impression that teachers who have grown up in a CNE system will misunderstand the intentions of an OBE system. This presents several implementation problems. Indeed Shanks (1993:6) quoted by Towers (1992) cited teachers' limited understanding of OBE as a major reason for resisting its implementation. Therefore, any innovation will need to be introduced with caution as current expectations may provide substantial resistance. Presently I will consider the topic of teachers as "facilitators".

4.3.3.1 Teachers as "facilitators"

It is my impression that teachers at Mtunzini have an accurate understanding of their role as facilitator in an OBE-system. Take the example of Boetsap Kiwane's (a science teacher at Mtunzini) views who attended an in-service training course:

Boetsap: In OBE, my understanding is, you negotiate. You say, OK, we don't have a syllabus – we have a learning programme. Now, we need to do this: How can we best approach it? What do you think needs to happen ... It is the learners deciding, you know, who belongs where – the size, the number of people. Of course, the teacher still has a role of guiding, providing the guidelines in terms of how group work can function effectively, but more depends on the learners than on the teacher.

Although teachers may know the theory of how a facilitator differs from the role of a traditional teacher, Roth & Roychoudhury (1993:148) warn that the task of a facilitator is not an easy undertaking. Allowing students to choose problems of their own interest entails an underlying intellectual expectation from the teacher. Students may come up with problems that require an in-depth knowledge of the subject matter on the part of the teacher as facilitator. Furthermore, teachers may struggle to guide and advise because of their unfamiliarity with these tasks.

Considering Mtunzini, may I refer the reader to section 4.2.2. on page 117 entitled: *The qualifications of teachers*. A full 34% of teachers only have limited expertise and therefore I have my reservations as to the ability of these teachers to answer questions directed from learners which may require deep insight.

Martin-knief & Uhrmacher (1992:266-268) further confirm my suspicions by expanding upon the difficulties teachers experience when designing curricula. These authors cite lack of curriculum development experience on the part of teachers as a severe drawback threatening the implementation process. South African teachers have always had recourse to a syllabus in the past and the learning programme which Boetsap refers to may prove to be very challenging to design.

So much for my assumptions and apprehensions. I now plan to present three vignettes concerning the lessons which I observed at Mtunzini. They all involve grade 8 classes. The first two vignettes are a reconstruction of events which transpired in separate classrooms and illustrate a form of traditional teaching which impinges upon the expectations of the learner. The third vignette is a science lesson involving grade 8 learners studying the topic of electricity through the medium of group work experiments. The three vignettes will raise several key systemic issues pertaining to OBE and its successful implementation.

4.4 Vignettes : Teaching and learning at Mtunzini

4.4.1. Vignette 1 A grade 8 English class

The first class I observed was a grade 8 English class. The questions relating to the comprehension were written on the board before the start of the lesson. The learners were expected to have read the book and answered the questions.

The teacher, for the most part, sat in the position indicated on the sketch and directed the entire operation. After reading the question on the board, he would ask the class for volunteers to answer the question. On a rare occasion, a more competent learner would venture an answer by raising his or her hand, and then stand up and read what he or she had prepared.

The teacher would either commend the learner for a good attempt or dismiss any wrong answers. Later in the lesson, if the learners did not succeed to his satisfaction, then they would be required to stand up and remain standing as photograph 4.5 indicates.

This approach should be denounced in the strongest possible terms in my opinion. The reason is by punishing the learner through humiliation it is pernicious in that negative feelings become associated with English classes and more specifically with the English language. The teacher administered this form of punishment out of frustration because he discovered that many learners had not done their homework and were merely copying down what other learners were reciting. To further fuel his anger, he caught a learner who had fallen asleep. Thus, if learners could not supply correct answers, were caught sleeping or had not done their homework, they were required to remain standing.

The lesson was entirely teacher directed and soon lost its appeal for learners who were obviously bored. This boredom was clearly noted when one learner threw a pen at one of her peers while the teacher's attention was occupied with another matter.

By the time the end of the lesson was approaching, those learners marked with an asterisk (L*) were asked to remain standing. Once the siren had sounded, learners wasted no time in packing up and joining the fray in the corridors outside.

The seating plans observed during an English class

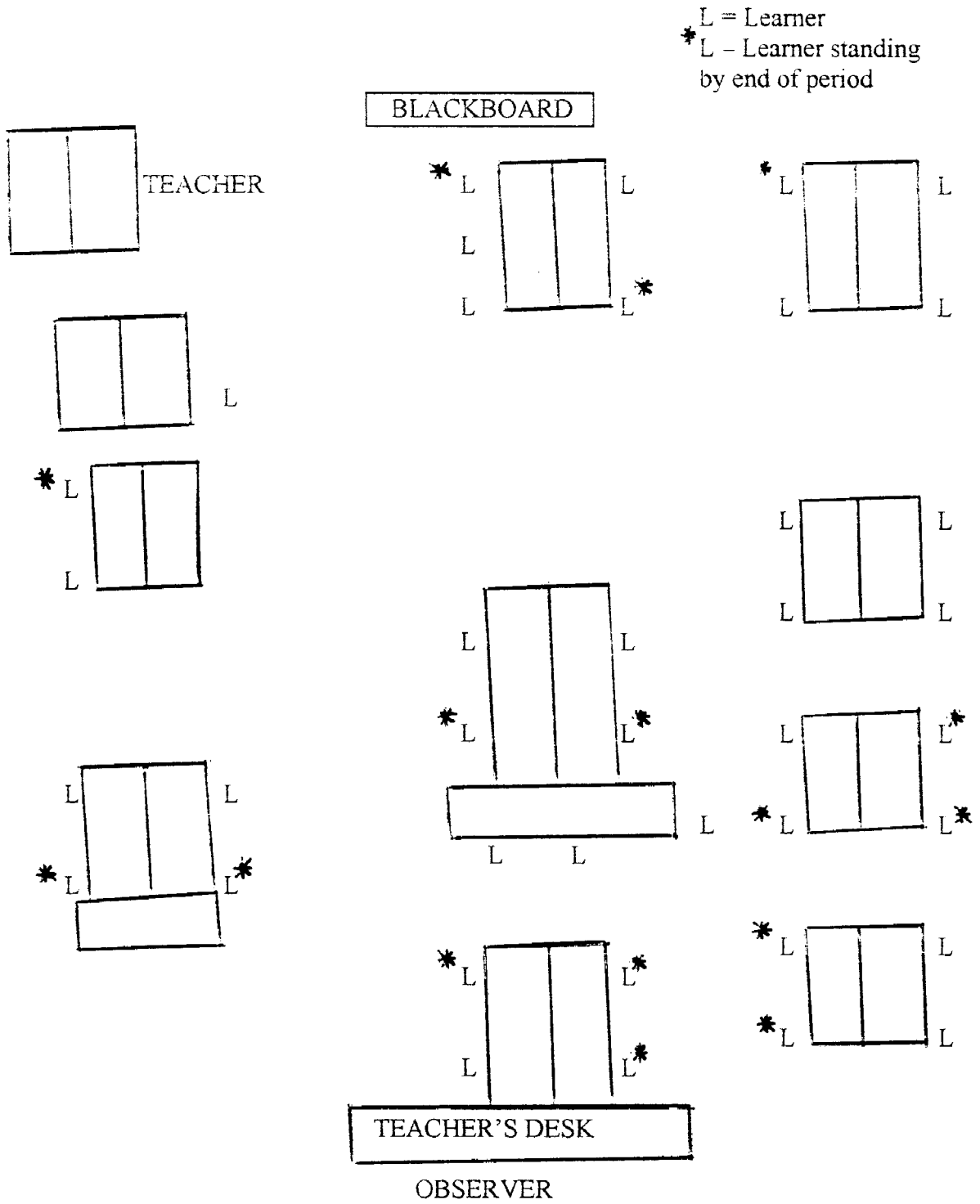


Figure 4.2



4.5 Learners who remained standing in an English class



4.6 Business Economics teacher summarising answers on the blackboard

4.4.2. Vignette 2: A grade 8 Business Economics lesson

The lesson was a revision lesson, because the exams were looming not two weeks away. The learners were asked to read through a passage for homework and during this lesson, the teacher questioned their recall of the facts. Interestingly enough, the passage which the learners were required to read was their notes which amounted to about 13 papers. I found this strange because even at grade 8 level, one may expect learners to be able to cope with more than 13 pages in five months!

The lesson, however, began with the teacher asking the learners to define business economics. One learner at the back was observed to stand up and read the definition from her notes. A rapid discharge of questioning would ensue with the eventual answering by the learners who correctly identified the answer which was in their notes. This pattern of questioning and answering characterised the lesson. Once a question had been proffered, the teacher then summarised the answers on the board shown in photograph 4.6.

What I found disturbing was the fact that the teacher, after asking a question or making a statement, would repeat it, sometimes ten or fifteen times, before a response would be elicited. The following transcript excerpt of the lesson illustrates this interrogation approach of the teacher and the effects on the learner. The teacher is referring to the four basic human needs.

Teacher: The third type of human need is ...?

Learner: Clothing.

Teacher: Clothing [writing on the board] ... It is a basic human need ...
Clothing, a basic human need, you agree?

Class: Yes.

Teacher: Clothing, a basic human need. You agree? You need it. If you don't have something on, can you survive? If you don't have something on, can you survive? If you don't have something on, can you survive? Clothing – a basic human need. Why?

Learners: Yes [Kids laughter] ... [Quite some confusion].

Teacher: Clothing, a basic human need. Why?

Learners: [Confusion, laughter and joking] ... [short burst of loud talking in class].

Teacher: Is clothing a basic human need!?

Learners: Yes! Yes!

Teacher: Can you survive without clothing on? ...

Learners: [Confusion].

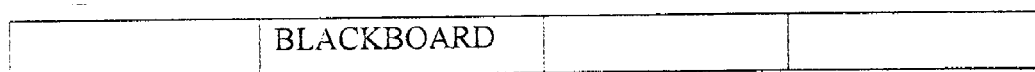
Teacher: Is clothing a basic human need?

Learners: Yes! Yes!

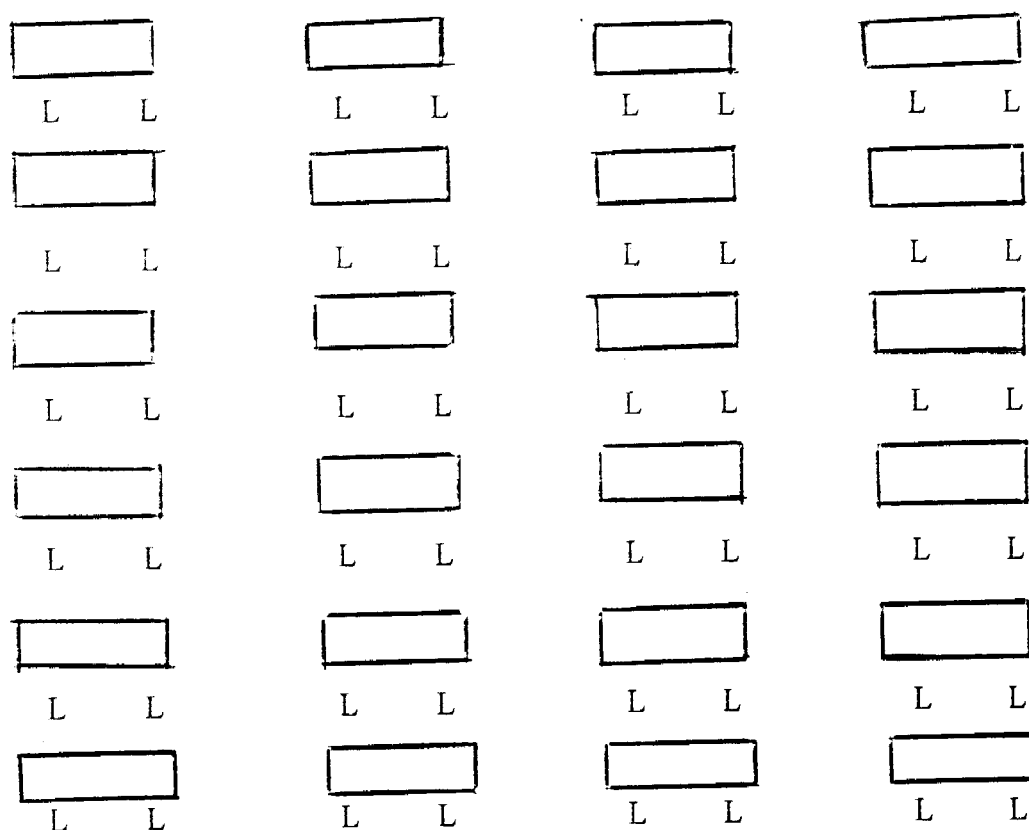
Teacher: We say it is basic because we cannot survive without it. We cannot survive without them ... What will happen if you do not wear clothes? ... Our forefathers survived without clothes ... so why do we saying (sic) that clothing is a basic human need?

Learner: [Reading from notes] It protects us from animals and elements.

Teacher: Clothing protects us from the elements, the sun, rain ...



TEACHER



Seating plan observed during a Business Economics class

Figure 4.3

4.4.3 Commentary

In summary, after reading the two vignettes thus far, the reader will probably realise that my fears and apprehensions which I stated earlier are well founded.

As far as fundamental pedagogics is concerned, we can see it clearly manifested in both the English and Business Economics classes. The mechanistic style of triadic dialogue, described by Jones (1997:563) who refers to the work of Mehan & Silverman (1985), which

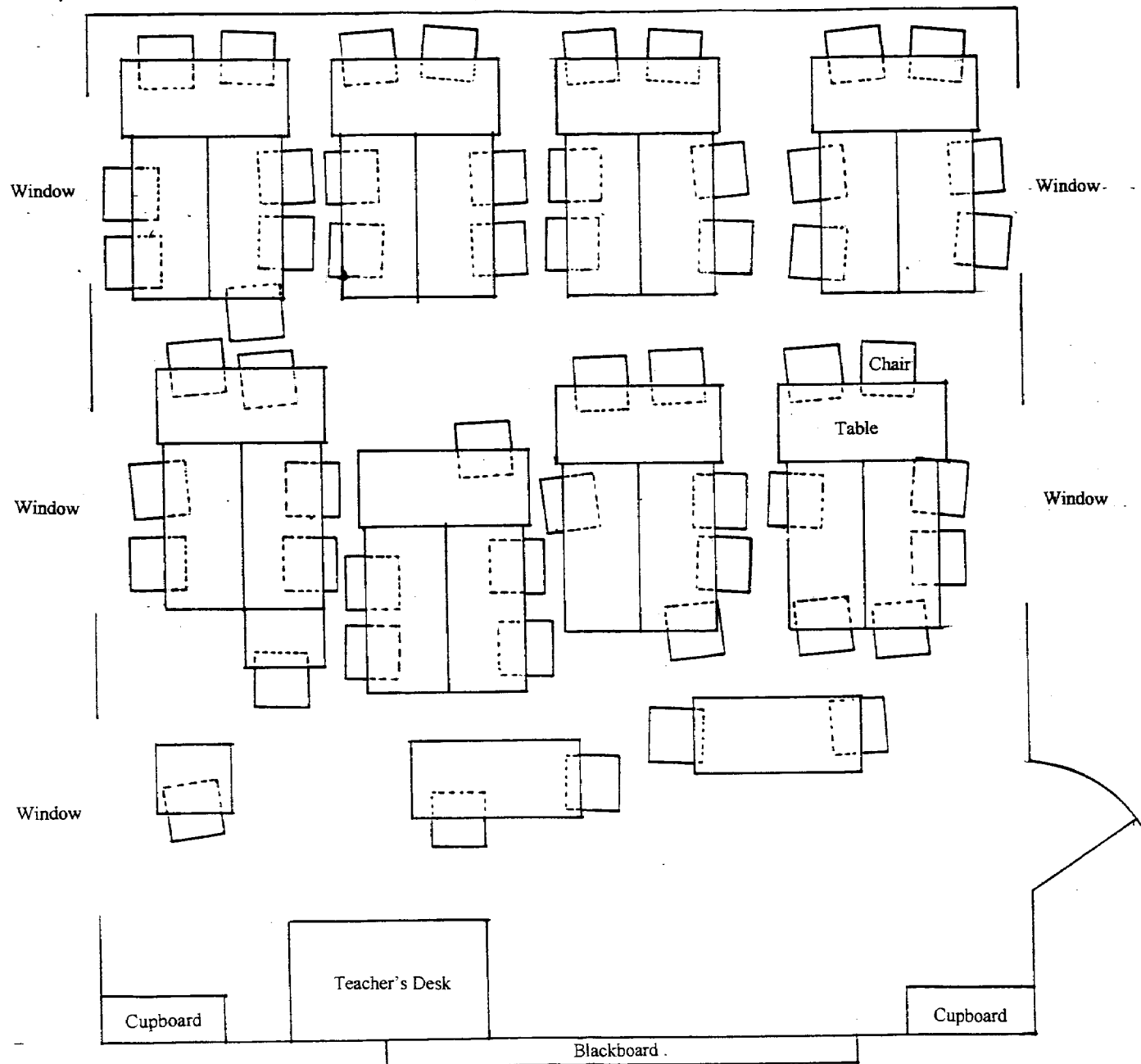
follows the pattern of teacher question, child response and then teacher approval or denial is in sharp relief.

In addition, I noticed the unimaginative presentation of the lessons where the teachers made use of the chalkboard as the only teaching aid. The learners, after a short while, soon became disengaged and one learner in the English class fell asleep in concession to the boredom. Apparently, this excessive use of the chalkboard is fairly pervasive throughout the school. During the interviews with the learners, they all commented on how they were expected to transcribe reams of teacher's notes once it had been explained to them by the teacher. The message gained from these lessons was the teacher was the authority and the learner the receptacle. It was the teacher's responsibility to control the learners. This then became their frame of reference in my opinion, expecting the practice to be transferred to the science classroom.

The second point to gather from these lessons is the use made of English by the learners. The Xhosa children struggled to overcome the language barrier, and as a recourse read the answers from their notes. There was no attempt made to paraphrase their notes and converse freely.

Wertsch (1991), as quoted in O'Loughlin (1992:814-815), explains why these circumstances should prevail:

The reason is students may come to school with a diversity of voices and sociocultural perspectives, but teachers use the fairly uniform speech genre of formal instruction. This translates into the teachers' insistence that their preferred speech genre be used instead of their students' voices. Rarely, if ever, is it the teacher's intention to seek information or provoke dialogue. Rather, the process is regulated by the teacher. [Superb examples of this are provided in the two vignettes.]



MRS KHUMALO'S CLASSROOM

Scale 1m:3cm

Figure 4.4

4.4.4. Vignette 3: A grade 8 Science class

This vignette describes events which unfolded in a Science lesson of Jacky Khumalo where she employed the use of group work. To do justice to the issues of small classrooms in relation to large numbers of learners and their resulting difficulties, I have included in figure 4.4, a scale drawing of the classroom and its furniture.

Jacky's class is a bleak shoe-box of a room. Since the lights were all out of order, it was generally dark and uninviting. On closer inspection, I discovered that it was not so much the lights which were defective, but the problem may be attributed more to the absence of fuses. Notwithstanding this, there were three large windows on the southerly side complemented by two smaller ones on the opposite side. The classroom had one broken window, probably the result of some childish misdemeanour since boys were accustomed to playing football on a nearby netball court.

The reader will notice from the diagram that provision in the classroom has been made for group work. Generally, three separate desks were positioned alongside one another allowing six to eight learners to form a group. This is commendable on the part of Jacky, but I urge the reader to reflect upon the challenges posed when trying to navigate between the groups. To reinforce the idea, view photograph 4.7.

As for the décor of the classroom, it was completely destitute of any colour. There were no displays on the walls, either professionally printed or student originated. In summary, Jacky's class was dark, dusty, dull, crowded and unpleasant. A most uninspiring learning environment.

4.4.4.1. A lesson on parallel and series circuits

The diagram in figure 4.5 below shows the class design.

At the start of the lesson Jacky referred the class to the teacher's notes recorded in appendix H. It required learners to set up and explain the relative brightness of bulbs in series and parallel.



Photograph illustrating
crowded conditions
in a science class



4.8

Learners of target group
around a circuit board



4.9

Jacky Khumalo in
background admonishing
learners for misbehaving

4.10



4.11



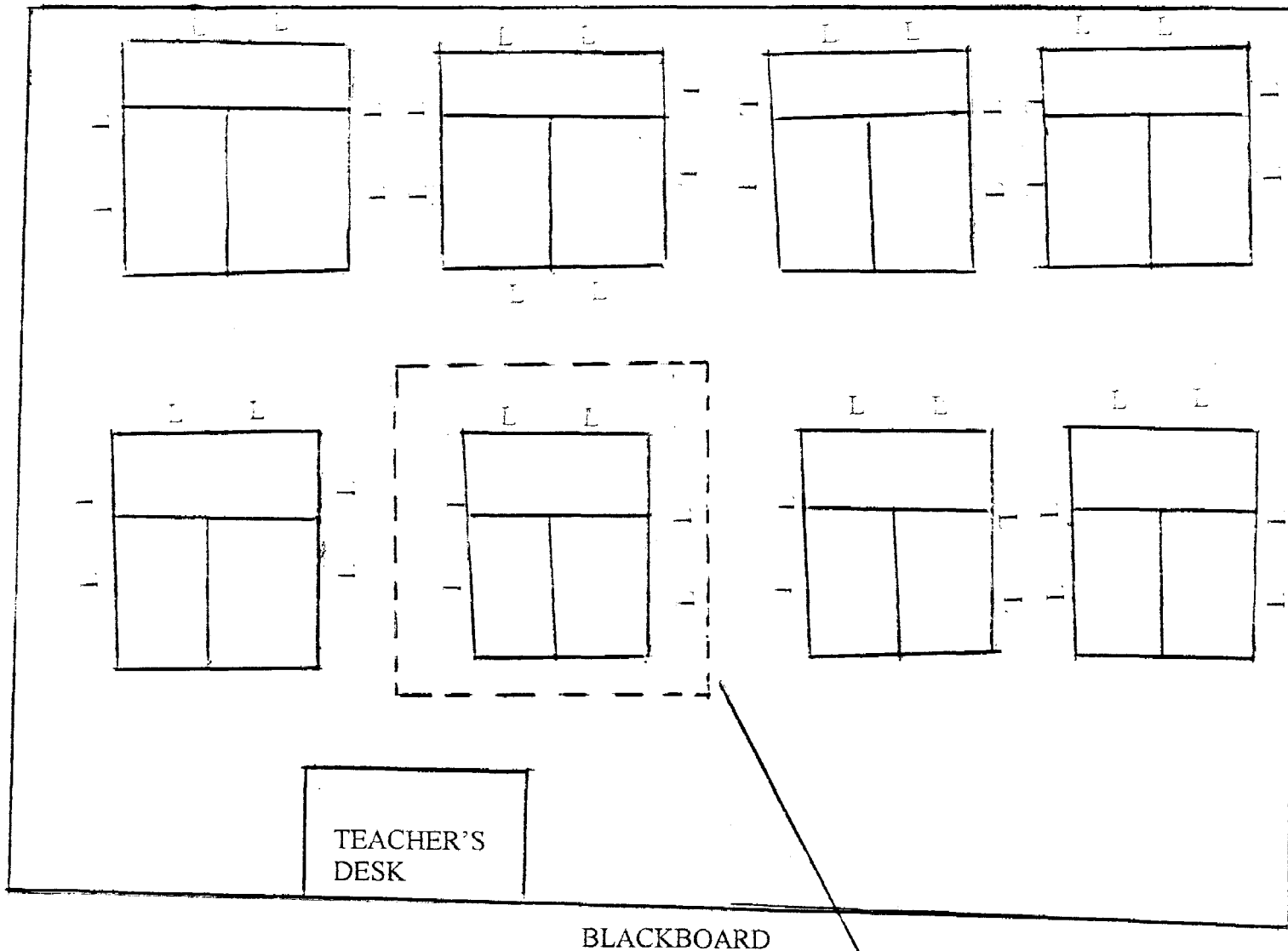
Learners struggling
to proffer contributions

4.12



Seating plan observed during Ms Khumalo's Science class

L = Learner



ENLARGEMENT OF MY
TARGET GROUP

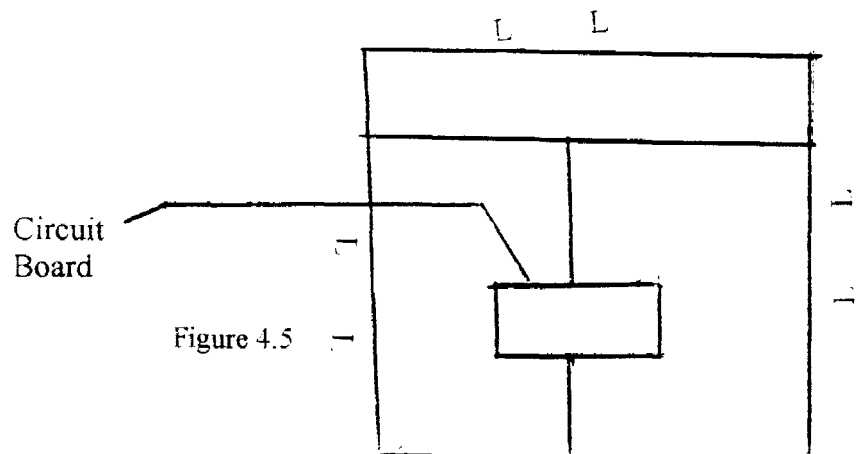


Figure 4.5

As soon as the learners received their instructions, they continued with the assembly. I was mainly focused upon my target group indicated on the diagram, (figure 4.5) and shown in photograph 4.8. The photograph illustrates the difficulty of teaching in this vein. There were seven learners assigned to one circuit board. A circuit board is difficult to manipulate and with so many “cooks”, I am sure the broth was not difficult to spoil. Contributions were rapidly offered by all the learners to the one or two dominant members who actually handled the apparatus. Photographs 4.10–4.12 provides the reader with clear evidence of how impractical it is to have so many learners in close proximity around one circuit board.

Misconceptions easily arise under such conditions. I noticed that at one stage the learners set up the following circuit in figure 4.6.

Since the globes were located one below the other according to figure 4.7, the learners tenaciously believed that the circuit they had set up was a parallel circuit. They argued that bulbs were located one below the other according to figure 4.6. I tolerated their misconceptions for a while and continued to show them a true parallel circuit while asking them to compare the corresponding brightness of the bulbs in each case. Once achieved, they began to realise that the circuit they originally identified as a parallel circuit was in actual fact a series circuit.

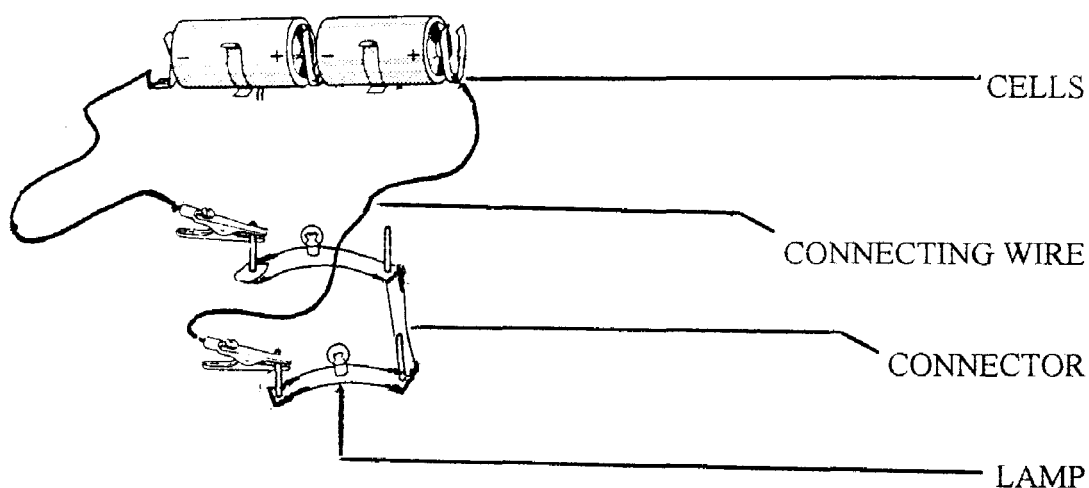


Figure 4.6

Circuit assembled by learners who believed that this is a parallel circuit

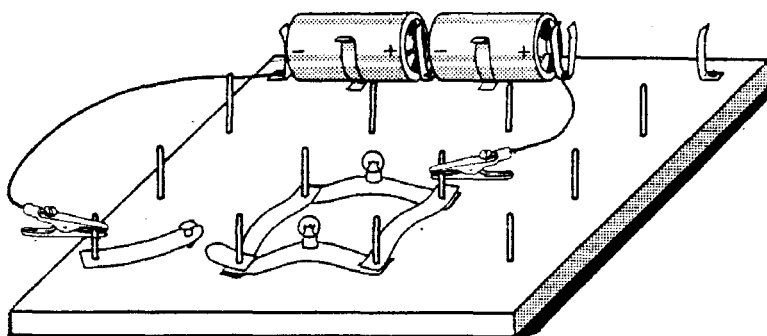


Figure 4.7

Diagram in textbook showing a parallel circuit

This was a time consuming endeavour because two separate circuits had to be arranged to make a fair comparison and the whole reconstruction process must have lasted ten minutes. This was a luxury which an observer such as myself could afford, but what about Jacky? She had to attend to seven other groups while maintaining order. Photograph 4.20 shows her in full battle cry admonishing learners who were misbehaving. I inquired where she perceived her problems to lie in such a group work situation:

Jacky: Sometimes you can be a little too, look at one group ... then if you spend more time with that group it may happen that you may not go to the rest of the groups at the same time ...

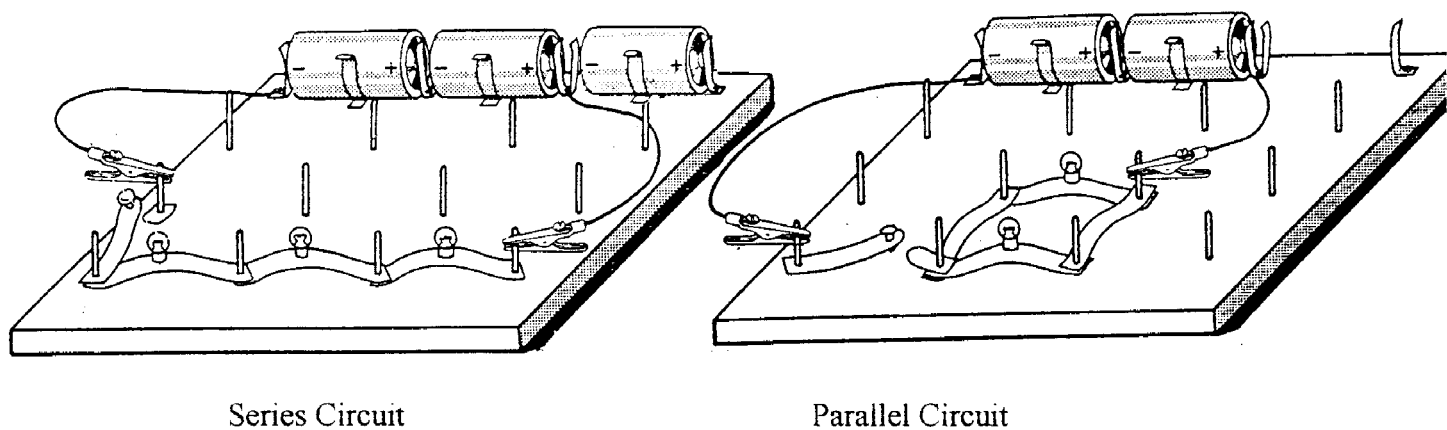
Interviewer: Right. So which groups tend to get more of your attention?

Jacky: Those who are lacking, those who are lacking ... Some of them will not be able to grasp the concept very easily ... so you need to spend more time. Then that eventually will make you not reaching the whole class in one period.

Jacky makes the interesting point that the time period of 50 minutes is too short to ensure that all learners have grasped the concepts. In final summation of her lesson on series and parallel circuits, to make up for much needed time, she called for the best circuit boards and asked for the learners to congregate around her.

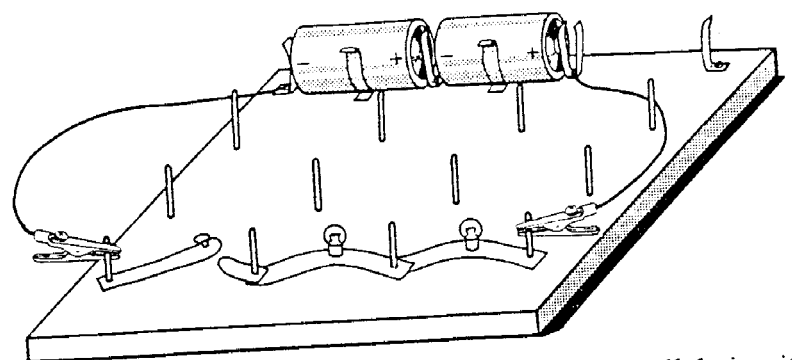
The fifty learners then crowded around the display near the back, climbing on desks and chairs, craning their necks to gain the best view. Several learners towards the rear of the gathering could not see and so became bored and mischievous. This behaviour degenerated into the physical assault of learners near the front. Worse still, Jacky's concluding efforts resulted in the learners developing misconceptions. The two circuits which were displayed had the appearance shown in figure 4.8.

Problems arose because instead of learners associating a series circuit with one long row of bulbs and a parallel circuit as one comprising bulbs arranged one below the other, learners thought that any circuit with three cells and three bulbs was a series circuit. Similarly, any circuit with two cells and two bulbs was immediately a parallel circuit. Therefore, it was not uncommon for the circuit in figure 4.9 to be labelled a parallel circuit.



Series and parallel circuits

Figure 4.8



A circuit erroneously labelled by learners as a parallel circuit

Figure 4.9

I noticed that this error was continually made by these learners in subsequent lessons. These errors and difficulties, I believe, would not ordinarily arise if the classes were not so large, the resources so scarce and the time duration of lessons so curtailed.

To conclude this section of the case study I will presently embark upon a discussion of key issues relating to the systemic nature of schools as they concern OBE. The issues considered are time scheduling, unforeseen events which caused time wastage, an integrated curriculum, resources, and assessment.

4.5. Key issues relating to the systemic nature of schools as they concern OBE

4.5.1. The issue of time scheduling

The ubiquitous time table and the allocation of separate periods to various subjects is prominent at Mtunzini. The fact that science lessons are only 50 minutes long is only one problem. More severe is the issue of only having three lessons per six day cycle which presents further complications. Jacky explains:

Jacky: Standard 6 [Grade 8], they have only three for one class per cycle. So in a cycle you may see one class only once. So it means that in two weeks time you will do one concept in different periods in one class.

Interviewer: And how does that work? Do you find that, that eh ... it helps good understanding or what is the result?

Jacky: ...But most of the cases when you come back, the first group that you have done it they forget. They think that they still know. Then you carry on and you find that they have forgotten everything.

Since any transformational OBE system will require substantial blocks of time, flexible scheduling is essential. This is a point well taken by the administration, but they do not seem to have any clear ideas on how to accomplish it. Reverend Solomon Hlobane grappled with my question of how to plan for rearranging the time scheduling.

Reverend Hlobane: Yes ... I think that, that is going to be a momentous task. You know, eh, it is something which we have got to work on ... eh ... jointly, eh, time here, eh ... I maybe understand you by, you talking about the period.

Interviewer: The actual period of contact between the teacher and the student.

Reverend: eh ... eh ... eh ... eh ... eh ... That is going to be opened, really.

Interviewer: Right.

Reverend: That is going to be opened. Maybe it is going to be decided by the department or even by that individual teacher because that is what we are doing already. Now, we are teaching up to twenty to two, but some people do come for extra, you know, classes. And eh ... ja, I mean OBE, you know it involves as well, you know, kids doing most of the work themselves. It might call upon us to come and do supervision where in the afternoon or even go out on excursions. You know, go out to the dumping place. Go out to the army. Go out, you know, and ...

Up to this point I have explained the limitations inherent in the current Mtunzini system concerning the time constraints and the recognition by the administration to have flexible scheduling in an OBE system, although no concrete plans exist. But now, what can be said for all the time lost because of unforeseen disruptions in the school? I have cited six incidents which occurred in as many weeks of my field work where time was inappropriately utilised.

4.5.2. Disruptions: The latent thief of time

4.5.2.1. Incident 1: Learners' exclusion from class

One morning I wished to observe Boetsap's Grade 11 Science class and planned the visit unannounced. To my dismay, a large contingent of learners were waiting outside and I assumed that Boetsap was absent that day. One learner, however, told me to knock and Boetsap, surprised to see me, allowed me to sit at the back of the classroom. I never under-

4.13



Learners excluded from school for being late

4.14



Learners who are not constructively engaged because of teacher absenteeism

4.15



engaged. They tend to sit in the sun, play cricket, football or rounders and a rare few may do some homework.



4.16 Items in a classroom which are at risk of being stolen

During one week, some six teachers were absent for various reasons. Assuming each teacher was responsible for 50 learners, I estimated that 300 learners were free to roam the school grounds. The intolerable noise levels began to disrupt some classes which were in session, much to the chagrin of some teachers.

On further investigation into the matter, I realised that the issue was fairly complex. According to Reverend Hlobane's explanation, the department never filled an Art and Afrikaans post, leaving the school with a teacher shortage. Then there was careers' week and some teachers made the unilateral decision to suspend class in favour of making sandwiches in the Home Economics room for the grade 11 and 12 learners. Perhaps worst of all, some learners who should have been in class played truant and joined their friends for a game of football.

I thought that a simple solution of making classrooms available would offer some relief. Unfortunately, the administration was reluctant to pursue this option, because they feared that

The Reverend Hlobane trains a wide sweeping spotlight on the matter explaining that many teachers may not share Abdul's enthusiasm.

Reverend: Well ... I feel many people will feel unhappy ... unhappy because of the transition, big transition. We, we have been having a syllabus, decided somewhere and we had to simply oblige to it and eh ... many of our teachers have done that successfully. We, now, it's now going to be thrown on us to decide, firstly, that is a golden opportunity ... It, it might be a risky business. Because there are still many of us who are under qualified ... I think some teachers will feel, you know, eh less equipped to go on their own ... eh ... They might need someone to guide them.

These two gentlemen are speaking hypothetically about issues which may arise in time to come. What are the current circumstances at Mtunzini? Jacky explained how the English and Science departments are recognising the need to cooperate in the interests of improving learners' English. If the English department needed a comprehension for example, then they would consider the recommendations of the Science department and set an exercise based upon a page from a science textbook.

After a careful review of the literature and my research data, I feel that perhaps Abdul is being too optimistic in thinking that it will not be a problem. As indicated in the literature review, school districts have been overwhelmed with the task since a commitment to integrate far exceeds a superficial mention of an example relating Physics and Geography. There may be considerable cognitive gain for learners if an integrated curriculum is implemented, but amounts to major headaches for teachers.

4.5.4. The issue of resources

The reader will recollect that in the introduction to this case study I explained what is available as it relates to Science education. In Boetsap Kiwane's opinion, there is a dearth of resources available, but he confidently elaborated at some length how OBE would remedy the situation.

Boetsap: ... you know what I like about OBE. It does not rely more on textbooks and all that. One can be innovative. It actually taps into

teachers', you know, creativity ... eh, you can be able to use resources, I mean, take natural resources that are there. You don't have to pay anything to learn about Geography – just go outside and look at the ... if you are talking about landscape ... you don't have to pay anything. There are hills. You can see what you are talking about. If you are talking about rock formations, there are rocks outside.

Lunenburg (1992:15) quotes the research of Brown (1991), Eposito (1989) and Hess (1991), to the effect that in an OBE system which Boetsap envisages, provision needs to be made for the busing arrangements of learners and their teachers. This has resulted in soaring transportation costs which Mtunzini can ill-afford. Therefore, Boetsap's plans of trying to cope with scarce resources will run aground upon a reef of a different kind, but tantamount to limited funding.

I believe Reverend Hlobane is far more realistic, acknowledging the fact that resources are in limited supply and not likely to be replenished by the department. However, he expresses the hope that existing resources will be exploited to their maximum potential while teachers employ creativity to expand upon them.

To cast the issue within a Science education framework, George (1993:19) regards material resources in this context to be chemicals and laboratory equipment. She contends that most curriculum developers ascribe the following benefits as a result of the inclusion of practical work: (i) it elucidates theory; (ii) it exposes students to the way scientists operate; (iii) it promotes practical skills; and (iv) it motivates students.

George (1993:21) balances these perceived benefits however, with the evidence of Clarke (1983) who argues that no studies conclusively prove that there are pay-offs for students who are exposed to these technologies. George (*ibid*) and George (1992:106) then forwards a case for the compilation and use of indigenous knowledge, but explains that science teachers in developing countries, of which South Africa is a part, have neither the time nor the inclination to research these possibilities thoroughly.

In the case of Mtunzini, some commercial resources such as circuit boards are available and can be used to their fullest potential. This is only one source in my opinion. The school is also exposed to a rich heritage of African culture because of its location and personnel. It may be of some advantage to tap into these resources, perhaps with the assistance of Rhodes University, as Reverend Hlobane repeatedly suggested.

4.5.5. The issue of assessment

Developmental assessment as an addition to the more familiar summative variety places enormous strain upon teachers as reported in the literature review. When I asked Reverend Hlobane for his impressions, these were his comments:

Reverend: ... even the form of assessment which we are going to use ... eh ... and here one is not that sensitive, but, that is, that is going to come upon us heavy. You know, we have got to devise means of going ... I mean, of actually tackling it ... It is going to involve a lot of you know, time ... eh, are are going to be strained as well ... stressed.

Stress and strain may be the thoughts conjured in teachers' minds when contemplating the effort and time expenditures associated with assessment. This being the case, however, it was not a concept entirely foreign to Mtunzini. Abdul explained his approach to developmental assessment.

He showed me a test he gave to one of his classes out of 100. Question 3 was particularly difficult and learners may have only scored 5 out of 30. In class, Abdul reviewed this question with the learners and then told them to prepare the question for the following day's test. Second time around, the total for the question was 20 marks and for each mistake he would deduct 5 marks. A learner may now receive 15 out of 20 which translates into 15 out of the original 30; some improvement on the previous 5 marks. These 15 marks are then added to the learners' total which inflates their results. Abdul admitted that this was time consuming for him, but he had the learners' best interests at heart and was satisfied with any improvements.

It is now my intention to focus my attention upon my own course which I designed and implemented with special referral to teacher demonstrations as a means of coping with limited resources. I will question the efficacy of this resort since it influences the planning of many science teachers throughout the developing world.

4.6. My own course

4.6.1. Introduction

In light of the evidence I was gathering at Mtunzini, and my experiences at St Sebastian's, I formulated two outcomes which the learners were to demonstrate. Both outcomes were process oriented.

Outcome 1

Learners, when given adapted scientific articles, were to analyse these carefully in groups and then collectively develop a presentation explaining the essence of the concepts it referred to.

Outcome 2

Learners were to demonstrate the process skill of 'prediction' when conducting investigations to explore electrical phenomena.

The notes I used in this course are to be found in appendix I.

By the time I arrived at Mtunzini, I had emerged from three months of field work and was soberly aware of the limitations of grade 8s. At Mtunzini I was dealing with second or even third English language speakers and whatever course was pursued, I knew that caution was of paramount importance.

To begin with, I decided to remain with the policy of allowing learners to perform as much practical work as possible while complementing their experiences with explanations. Being cognizant of the rigid didactic style of teaching to which they had grown accustomed illustrated by the vignettes presented earlier, I deemed it more prudent not to deviate too far from their expectations to begin with. I hoped to introduce my process approach gently as the learners acclimatized to my intrusion.

4.6.2. The progression of conceptual development

Referring to figure 4.10, the reader will see a concept map which demonstrates the conceptual progression. Through a process of discovery, I allowed learners to first assemble some simple circuits in an attempt to make the bulbs shine. It was a warm sunny day, so I instructed the learners to work on the basket ball court outside. Learners, divided into groups of between five and nine, worked on the assignment.

4.6.2.1. Problems of communication

The following lesson we returned to the classroom and through a questioning and answering lesson, I attempted to elicit what the learners had gathered from the practical. What I discovered early on was that the students were terribly reticent, and it was like 'drawing teeth' trying to encourage these learners to speak. Jegede's (1997:9) explanation of these circumstances is based on socio-cultural influences. He speaks about the high regard children have for authority figures in their traditional society. This locus of authority is now transferred into the classroom where the science teacher becomes the elder and 'knows all' in issues relating to scientific facts, processes, principles and laws. It is the learner's responsibility to listen and absorb. Jegede (1997:9-10) analyses the situation more deeply in terms of community goal structures, traditional world view, societal expectations and the sacredness of Science. I will consider each aspect briefly.

Concerning the community goal structure inherent in traditional African culture, people are interdependent but school science suggests that they are to be individualistic and competitive. For example examinees usually write tests in isolation. This causes a disturbance in the mind of the child and so he or she would prefer not to venture any answers. The traditional worldview of the African suggests a strong belief in the supernatural. Since Science is more "down-to-earth", conflict arises and the matter of societal expectations is also subject to debate. An African child forms an integral constituent of a community; any failure on his or her part means the community has failed. Hence, in my classroom, if a child proffers an incorrect answer then it may cause deep embarrassment, because it reflects strongly on home, friends and community. Therefore, it is wiser not to risk any replies. Finally, Science is considered to be sacred. The community sees the products of Science in the form of technology which controls their lives. Science is something which requires magical explanations which the African sees as being incompatible with their thoughts. The result is

fear; fear of the subject and fear to pursue the course of logical reasoning through questioning and discussion

Concept map showing progression of concepts

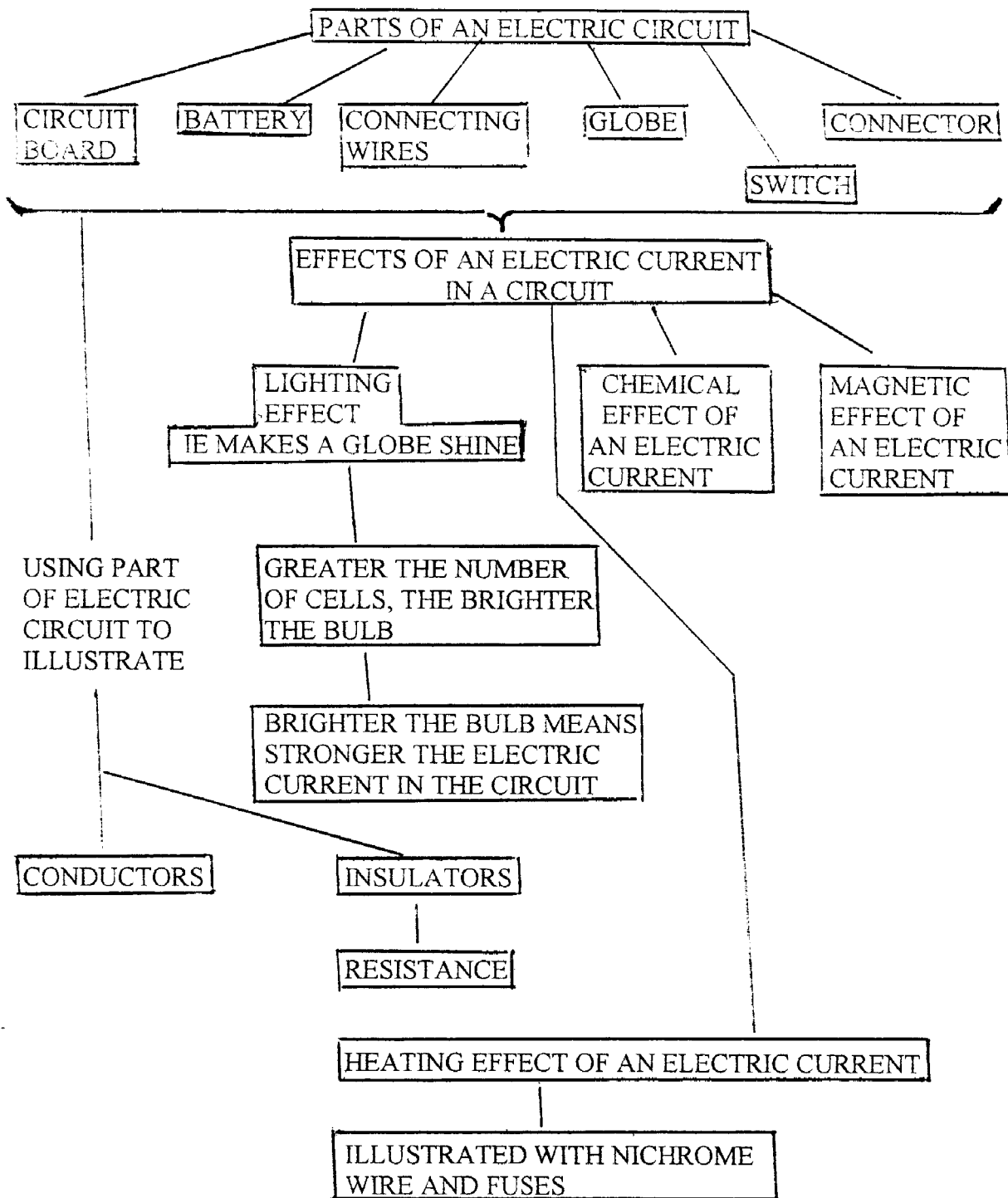


Figure 4.10

These are Jegede's views. Abdul Patel (Science teacher at Mtunzini) confirmed the socio-cultural perspective, but believed that in the South African context, fundamental pedagogics was so autocratic in its execution that these learners had been beaten into submission and now remain silent.

I would agree with both Jegede's and Abdul's opinions, but I posit one further explanation. My view is the learner is compelled to study Science through the medium of English and the grade 8 learners of Mtunzini are severely lacking in their linguistic ability.

To prove my point I devised a simple comprehension test requiring some basic understanding of electricity which was supposedly dealt with in class prior to the test. The comprehension test and a few contributions are to be found in appendix J as proof of how deficient the learners are. Furthermore, in appendix K, I have included learners' written contributions to their worksheet assignment. It is deeply disconcerting that the learners should be lacking in this area. Germann & Aram (1996:778) remind readers that comprehension skills are crucial to construct appropriate meaning about the task. This is why I placed such a high emphasis on process and reading skills, because learners may be able to assemble a circuit board and make a bulb shine, but never have the linguistic capability to explain why. Peruse the evidence supporting my viewpoint in appendices J and K.

It is believed that writing is essential for a learner's education; a viewpoint supported by Fellows (1994:987). From a constructivist frame of reference, Fellows (*ibid*) argues that the "looking-back" nature of writing matches the nature of changing knowledge and encourages students to consider alternative understandings. Tierney, Soter, O'Flahavan & McGinley (1989), quoted in Fellows (*ibid*) researched students' writing with and without a reading component and found that writing associated with reading activities enabled students to extend their thinking and acquire new perspectives on topics.

The problem with pursuing a process approach involving reading and writing is that science literature is generally esoteric, laced with jargon beyond the reach of English second language learners. Moje (1995:362) refers to a science teacher's experiences when stressing reading assignments. These were her comments:

This is not a novel that you're reading ... this is a Science book. You have to hang tough and eventually you'll get it. You may have to read it once, twice, maybe 10 times to get the concepts that are talked about in these chapters.

4.6.2.2. A course of action

On the one hand were learners, severely deficient in English, and yet on the other hand, the experts assert that reading and writing are key elements in the learners' conceptual developments. To make some progress in meeting the requirements of my first outcome, namely that learners read in groups and deliver a presentation, I decided to select a few relevant journal articles. These articles and their adapted versions are found in appendix L and are related to the production of electricity and the negative and positive effects of low intensity magnetic fields surrounding current carrying conductors.

In keeping with the suggestions of Wellington (1993:50) I carefully selected the articles from *Time* and *New Scientist*. I then paraphrased the articles, writing them in more accessible English.

The assignment which accompanied the articles was designed to assist learners to acquire a better understanding of the articles by allowing them to work in groups and thereafter plan a team teaching exercise. The collaborative assignment is very beneficial according to Pizzini & Shepardson (1992:244) who quote the research of Hertz-Lazarowitz, Baird, Webb & Lazarowitz (1984) who claimed that student autonomy increases student learning via increased student-student interactions.

Unfortunately, this team teaching exercise together with my process experimental approach stressing 'prediction' never quite became airborne. Circumstances which included time constraints, pressure of June exams and an impending teacher strike forced my hand. Not to alienate the learner, I first decided to build up some momentum relying on traditional pedagogy to navigate through the syllabus, concentrating upon the basic concepts. I initially planned to introduce the readings and process skill of 'prediction' towards the culmination of the course. Unfortunately, this was not to be and I had to collapse two periods into one and resorted to the method of a teaching demonstration lesson to elucidate the concepts of the heating and magnetic effects of an electric current.

This strategy is standard procedure and is followed by science teachers the world over. Certainly in an environment such as Mtunzini where there exists exam exigencies and a shortage of resources, such a policy is inevitable. To conclude this case study, I will describe events during the demonstrations and the results of this teaching practice as an option for science teachers in similar circumstances.

4.6.2.2.1. Vignette: Practical demonstration sessions: Are they successful?

I first refer the reader to two worksheets in appendix H. The first is entitled “Resistance” and overleaf is its application: “The fuse – The policeman of electric circuits”. The second worksheet is a composite of the chemical effect and the magnetic effect of an electric current.

The culmination of my lesson series which deals with the chemical and magnetic effects of an electric current, was originally planned to contain some aspects of the process approach discussed earlier. Unfortunately time constraints would not permit me to allow learners an opportunity to do the experiments on their own. I had to resort to a teacher demonstration.

To contextualise the teacher demonstration involving chemical and magnetic effects, it is important to briefly discuss the preceding two lessons. In the first of the two lessons, leading up to the teacher demonstration, learners had the opportunity to conduct an experiment involving nichrome wire to establish the fact that it becomes hot when current passes through it. Learners then built circuits with steel wool fuses and so applied the concept of the heating effect of an electric current when the fuse “blew”.

The following lesson, of which photographs 4.17–4.19 bear witness, was a consolidation period where I demonstrated what the learners had already seen and assisted them with the written requirements of the assignment sheets. Of particular interest here is photograph 4.18 which indicates how desperate I had become on occasions to involve the learner and elicit contributions from them.

Unfortunately, a teacher strike was pending, end of term mark schedules were due, examinations were around the corner and the syllabus had to be completed by request of the regular class teacher. To meet these demands, I decided to do a two-in-one demonstration the

following period which would involve the chemical and magnetic effects of an electric current.

Photographs 4.20–4.22 show the apparatus which I had prepared and the accompanying board work to consolidate the notes. Pay careful attention to photograph 4.20. Nearest the tape recorder is a solution of copper II chloride into which is inserted carbon electrodes. On the edge of the table is my specially constructed wooden “E-frame” apparatus with a white platform upon which rests tiny plotting compasses surrounding a straight current carrying conductor. On the opposite side by the blackboard is a telegraph set to show a practical application of the magnetic effect of an electric current. The entire demonstration required at least 15 hours of prior thinking and preparation on my part to reach this stage. As events unfold, the reader can judge if my diligence was worth that expenditure of effort.

First, I have presented a transcript of events which occurred during the lesson, followed by a commentary.

Transcript

Teacher: What’s happening? It is changing colour – isn’t it? Changing colour from black to ...

Learner: Copper.

Teacher: Sort of a reddish. Now, now, if the solution here ... is copper chloride ... If the solution is copper chloride, what do you think that brown stuff is?

Learners: ...

Teacher: What is that brown stuff? ...

Learner: Rust.

Teacher: It is not quite rust, but sort of got its application. What do we call it? ... Take a guess.

Learner: Copper chloride solution is burning.

Teacher: You, we know that, but what is this reddish stuff? Oopsie, [dropped electrodes into the solution] ... It is simple copper metal. That's not the end of the story. Oopsie [dropped electrodes into the solution] ...

Look closely, get right down. What do you see at the ... this electrode?

Learner: Bubbles coming up.

Teacher: So, what is it? [Learners in small groups asked to come closer].

Learner: There are bubbles come from down here [Learners start shouting, laughing and joking in the class].

Teacher: [Stomp! Stomp! Stomp! With broomstick on the table]. Settle down! ... Grade 8! Grade 8! Grade 8! Listen up! [Stomp! Stomp! Stomp!] What are the bubbles?!

Learner: It is a gas. Hydrogen.

Teacher: No, not hydrogen. You smell it around swimming pools.

Learner: Oxygen.

Learner: Nitrogen

Teacher: No, people. Chlorine gas.



4.17

The author referring class to the appropriate notes



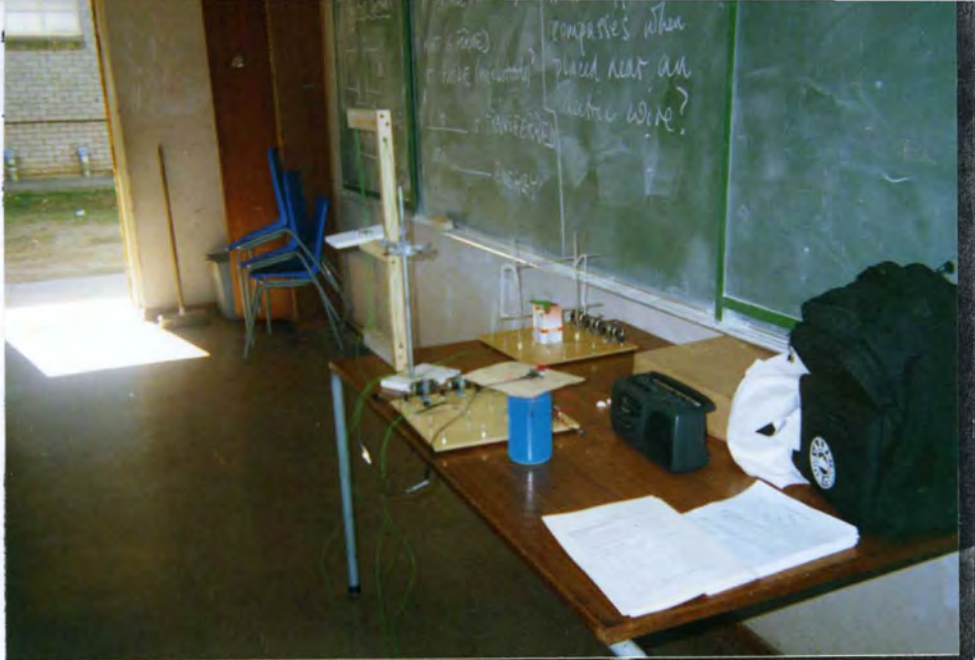
4.18

The author trying desperately to elicit contributions from the learners

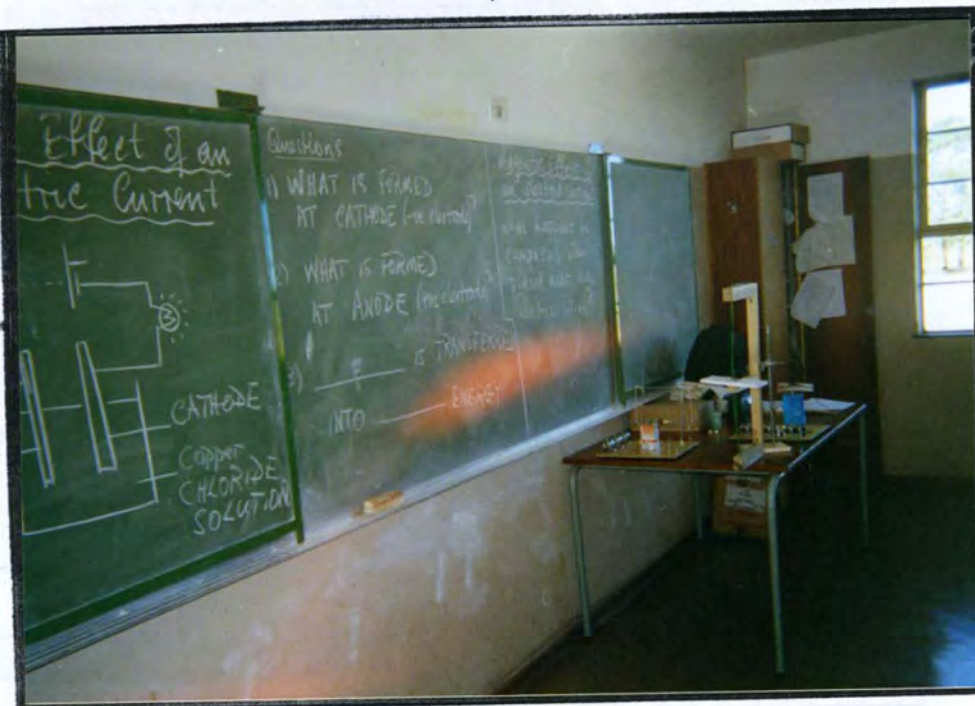


4.19

Author emphasising a point about 'fuses' on the board



4.20



4.21

Apparatus assembled in preparation for a practical demonstration of magnetic and chemical effects of an electric current



4.22

4.6.2.2.1.1. Commentary

The first point to notice in the transcript is that the moment there was a demonstration performed before the class, the situation became teacher-directed and it became a matter of control. You will note that I even had to shout above the noise to make myself heard.

The second point is the learners had no prior concept of what was taking place at the electrodes. Some suggested that rust was forming on the cathode, while gases such as hydrogen and oxygen were presumed to form at the anode. The best I could do was acknowledge their attempts at guessing the right answers, but because of time pressures I could not confront their misconceptions by asking them to spend time reading the explanation provided on the worksheet. I was compelled to submit and inform them of what was taking place. Therefore, I had sacrificed a key constructivist principle, not so much through ignorance, but because of the demands of the traditional schooling system. The constructivist approach takes time – no questions asked.

The demonstration of the magnetic effect of an electric current and its attendant explanation was handled in a similar teacher dominated fashion. In the test which was to follow the next day, I included the question shown in figure 4.11.

At least 95% of the learners who wrote the test believed the nail would get hot. This key piece of data shows the folly of my decision to handle such a broad spectrum of theory through practical demonstrations. The learners confused the heating of nichrome wire with the magnetic effect of an electric current. I deserve to be reprimanded for my error in judgement even in the face of a pressured programme.

Roth *et al* (1997:526) present a number of reasons why such demonstrations as mine are bound to fail. The relevant ones I have cited include:

- a) without a theory, students have difficulty in separating noise from signal;
- b) previously appropriated discourse interfered with the development of a new, situationally appropriate one;
- c) the overall context was such that many students did not consider demonstrations as something of importance; and

- d) students had no opportunities to test whether their descriptions and explanations of the event were viable.

Roth *et al*'s explanation is most revealing and serves to illustrate why learners become so confused. Time must be made available so learners can access relevant theory, and apply their knowledge through discussion in a work oriented environment.

Test question concerning magnetic effect of an electric current.

Question 9

Have a look at the sketch. Say what you think will happen to the nail.

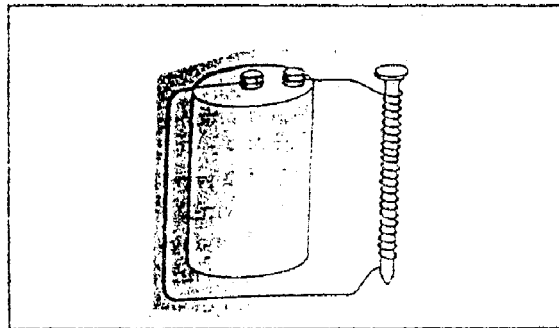


Figure 4.11

4.7. Conclusion

There is a popular perception that OBE is a 'white elephant' and will never get off the ground. When doing my field work at Mtunzini, I heard countless arguments of how lack of resources pose the greatest danger to its implementation.

I believe such a threat as scarce resources pales into insignificance in comparison with the need to have a change of mind-set. I concur with Abdul Patel who laboured the point that resources at grades 8 and 9 are not an issue. Rather, what is more important is for the teacher, learner, parent and administrator to change their philosophical outlook from objectivism to social constructivism. Without such a transition, no change is possible.

To further augment this view, consider the case of Johnson City's version of OBE labelled the Outcomes Driven Developmental Model (ODDM). Johnson City, New York, USA, report Evans & King (1994:14) is a depressed low – middle-class – community with few professional citizens and the second highest poverty rate of 10 urban districts in its county.

Notwithstanding this disadvantage, total restructuring based on OBE philosophy occurred and excellent results of its learners vindicated the decision. It seems, therefore, that Mtunzini is not beyond a successful implementation of OBE. It depends on the will of the people and a total restructuring policy based on constructivist principles.

Chapter 5 : A total systemic approach to restructuring

5.1 Introduction

A fundamental revelation of my case study research was that two competing philosophies cannot co-exist in the same classroom, school or education department. To support the philosophy of social constructivism which dovetails with the basic tenets of OBE, there must be a complementary systemic organization in the school to allow for such a policy. For example, it is senseless imposing finite time limits on every child in the school and then expect *all* learners to succeed. It is folly to isolate a single teacher in a classroom comprising 40 learners and demand that a syllabus be completed in such a way that all learning styles will be accommodated.

Teachers, learners and administrators must realise that they are all part of a system. Deming, quoted in Rhodes (1990a:34), provides one with the insight that this situation prevails because organizations are systems where “functions or activities work together for the aims of the organization”. Consequently, the transition from a traditional system to one supporting OBE is problematic. Brandt (1991:55) quotes Cohen who argues that all aspects of a curriculum are interrelated. It is impossible to make assessment changes without considering accountability which is not divorced from curriculum. It is therefore my contention that major structural changes in schools need to be effected to support OBE. The purpose of this chapter is to provide the reader with some practical advice on how to accomplish this Herculean task, given that most institutions in South Africa are cemented in the cloisters of their medieval thinking.

Fitzpatrick (1994:22-23) suggests that implementing OBE requires that four challenges be surmounted.

5.2. The four challenges to surmount to implement OBE

5.2.1. Building a shared vision

Fitzpatrick (*ibid*) recommends that if any change process is to be successful then it requires the input from the entire community. Members of the community extend beyond the teachers, administrators, learners and their parents to church and civic leaders and representatives of business and higher education communities. Once a forum is established then members are to develop a vision of the well educated learner.

The first point of departure to note here in comparison with the traditional system is South African schools are isolated islands in the community. Generally, parents, let alone the broader community, have had little to no say in the affairs of the school. These concerns have exclusively become the province of the expert teachers. If Fitzpatrick's advice is of substance then South African schools will need to open their doors to allow for wider contributions.

To expand upon Fitzpatrick's notion of the shared vision, Herman (1990:14) states that to achieve such a goal, it is imperative to formulate a strategic plan. To be successful in this regard, stakeholders' groups will need to engage in the following:

- ◆ reach consensus on the beliefs that provide the underpinnings for the culture of the school,
- ◆ collect important internal scanning data such as learner average test results and school climate measures, for example, the commitment of the learners,
- ◆ collect important external scanning data such as those related to demographic, political, economic and attitudinal data, and
- ◆ identify those few critical success factors, for example, resources and realistic teacher to pupil ratio, that are necessary to achieve a productive and caring school.

This research provides the "what is" and complements the "what-should-be" vision. The principal and his team of representatives then compile a mission statement which is a short disclosure describing the basic purpose of the school. Once achieved, Fitzpatrick (*ibid*) suggests employing organized abandonment.

5.2.2. Employing organized abandonment

The principal and representative teams then need to decide upon the exit course outcomes which relate strongly to the specific, learning area and critical cross-field outcomes. The course outcomes, performance criteria, rubrics and range statements need to be clearly refined and defined. It is of necessity to abandon tradition and such habits as covering the syllabus. This is a major obstacle in my opinion because changing tradition is tantamount to changing people's entrenched mind-sets.

Rhodes (1990b:26) speaks of the difficulties experienced by teachers making changes. He claims that a major stumbling block is teachers and administrators are so consumed in their work that they lose confidence in any suggestion of modifying their organizations systemically. Rhodes (*ibid*) elaborates that traditional models of schooling are so much part of teachers' instinctive thoughts that they are unable to identify the problems with the system's procedures. This is bound to create problems as Towers (1992:300) warns and may result in resistance by teachers who have poor understanding of OBE. It is my feeling that teachers feel they are doing their best and nothing extra can be done so why bother to make a transition? Teachers struggle to grasp O'Neil's (1993:8) concept that systemic change is necessary since it is mandatory that all learners should succeed and current systems are failing dismally.

Fitzpatrick (*ibid*) then includes "capacity building" as a requisite to advance systemic changes.

5.2.3. Capacity building

In order to mollify the concern of Towers (*ibid*) that teachers limited knowledge of OBE, Fitzpatrick (*ibid*) expresses the need for in-service training for all teachers and administrators who are in the forefront of education. The reason is it is they who must develop the technical skills to implement OBE. These programmes need to assist teachers to develop integrated curricula and performance based assessment. May I add that administrators will need to devise means of accommodating these curricula and forms of assessment within flexible time schedules.

Certainly if my case study research is of any credibility, the educators I interviewed believe that the department is falling short in the area of in-service training. The reader will recall from the St Sebastian's case study that teachers had not even mastered the rudimentary terminology of OBE. The situation was not that much improved at Mtunzini. Apparently one or two representatives from the school attended a course on OBE, and then had the responsibility of informing their colleagues. Unfortunately, the basic principles had not permeated through the system to the extent of influencing the teachers' classroom practice.

Fitzpatrick (*ibid*) then refers to organization capacity building, and stresses the importance of translating organizational development skills which are required to support systemic change

into standard operating procedures for the school district. My interpretation of this is that in any school district composed of several or many schools, there needs to be a common operating procedure throughout. This implies that schools who may have been separate entities before will need to communicate far more effectively. I should imagine that this is crucial, particularly if learners are to receive a comparable education if transferred from one school to another.

Finally, Fitzpatrick (*ibid*) advises the need for a commitment to a systems perspective.

5.2.4. Commitment to a systems perspective

By this stage the outcomes have been defined as the basis of the curriculum development efforts of the principal and his team. The circumstances have now matured enough to develop suitable instructional strategies and performance assessment measures, focusing upon what is valued rather than what is easily tested, but unrelated to the scope or rigour of the essential learning outcomes.

In summary, an outcomes-based system requires that the tested, taught and learned curricula be aligned with intended learning outcomes. Furthermore, the responsibility for developing the curriculum, designing instruction and learning experiences and administering the design and development of assessments of student learning and fulfilled within a collaborative effort based on a shared vision of the well-educated learner.

Very briefly, it is my intention to enumerate a few of the realities of restructuring as cited in the literature. This I consider important since educators must not be under any illusions when putting their hands to the plough.

5.3. The realities of restructuring

Westerberg & Brickley (1991:23) remind the would-be curriculum developer that it is "easier to talk than put things into practise".

Westerberg's & Brickley's (1991:23-25) list of realities, *inter alia*, include sacrifice, money, time to talk, outside perspectives, coping with fear and rumour, and being able to facilitate a political compromise. I will visit each reality in turn.

5.3.1. Sacrifice

Diligent work and sacrifice from all members of the school and staff is of paramount necessity. The example described by Westerberg & Brickley (*ibid*) is that of Littleton High School. The members of the steering committee convened each week for two and one-half hours. The principal dedicated a third to a half of his time to the project. Secretarial and clerical staff had added duties to keep pace with all the changes and meetings. Therefore, enormous amounts of energy had to be expended to make the project viable.

Since teachers and administrators will be sacrificing their time in developing outcomes and aligning curricula and assessment, I cannot help but contemplate the possible resistance from certain sectors. For example, a sports coach may be serving on a committee and need to sacrifice an afternoon or two each week of coaching. I would prefer not to think how such a suggestion would be received by St Sebastian's, where some of their grade 8s were participating in 24-hours of sport per week!

5.3.2. Money

Money is always of necessity. Money is needed to provide teachers and personnel with stipends for their release time to attend in-service training and curriculum development activities. In addition, money is required for the purchase of resources since OBE stresses that learners be able to "do" and not merely learn.

5.3.3. Talk

All the participant role players associated with a school need time for discussions and communication. Once again time needs to be made available; not easily orchestrated in some schools. The reader will recall that teachers at St Sebastian's are required to spend 80 hours per week attending to their basic commitments. OBE will now require more sacrifice or more realistically, some school traditions and activities will need to be sacrificed.

5.3.4. Outside perspectives

It is important that administrators realise that their schools are no longer bastions of independence. They need to invoke the services of education and business consultants who may assist in such areas as assessment strategies where the experience of teachers is particularly rarefied.

One aspect which impressed me about the Mtunzini administration was their recognition that expert input was required on the part of Rhodes University. Other schools need to follow Mtunzini's example and not try to isolate themselves.

5.3.5. Coping with fear and rumour

Westerberg & Brickley (*ibid*) comment on how quickly fear and rumours spread. To cope effectively, it is my opinion that open forums need to be staged so that wild accusations may be quashed.

5.3.6. Facilitating political compromise

It must be realised that different departments in a school are at different stages in the change process. Take Mtunzini, for example. The English and Science departments liaised closely with respect to the sharing of comprehension passages. However, other departments shared little in the way of resources or expertise. This may be attributed to the fact that each subject is treated as having its own unique structure. The reader will recollect in the St Sebastian's case study that I referred to this perspective on education as the 'structure of the disciplines'.

If OBE is to succeed with its emphasis upon holism then such obstinate attitudes need to be tempered to achieve political compromise.

In this final chapter I have described what is required to guide the complex system of a school towards one embracing the three fundamental premises of OBE. It will not be easily achieved. We can take it for granted that the roots will be bitter, but will the fruits be sweet?

I will now conclude my dissertation with a vision provided by Keefe *et al* (1992:23-24) of what actually takes place in a restructured school. In other words, what is the ideal which we should be striving towards?

5.4. The vision

The Keefe *et al* (*ibid*) account speaks of a large school which is divided into smaller schools where groups of 80 to 100 youngsters are served by four to five faculty members who have substantial autonomy. These units are akin to a federation making up the whole high school. The teachers and learners work together for three or four years and know each other well; teachers are able to personalize teaching and learning for each of their charges.

The schools' programmes have a clear focus for all students, without exception. They are of sweeping breadth and substantial depth. These programmes compel learners to be committed and emphasize knowledge and resourcefulness. The programmes focus on Mathematics and Science, on History and Philosophy, on Literature and other arts (often in combination), and on forms of expression, not only in English but also in a foreign language. The programmes insist that youngsters explain concepts in writing, orally, and through other media.

One quickly learns that a simplified and focused programme does not imply some kind of standardized approach. Quite to the contrary, when the formal curriculum is simplified and focused, the responsibilities of teachers become interconnected and focused, thus ultimately allowing a sharp reduction in the number of students assigned to each teacher. As the "loads" decline, greater attention to individual learning styles and interests can be attended to. The end result is a rich variety of means, tailored to individual students or groups of students, toward common ends.

The schools are noisier, seemingly less controlled. The timing of breaks in the classes is set by each separate school; there are no school-wide bells and thus fewer stampedes down the hallways at predictable times. As the faculty requires the learners to constantly display their work, the voices of learners are more likely to be heard than the voices of teachers. As a substantial portion of the work required is collaborative, conversations among students are frequent and of significance. One finds the school library both larger and busier than one traditionally expects.

The learners in the schools progress on the basis of their performance, on exhibitions. Thus, one finds only rough age-grading in classes. Further, one finds the objectives in courses more clearly defined: both students and teachers are clear on the scope and standard of the expected exhibitions before they start their work in the course. One listens to students and hears from them a much clearer sense of what they are doing and why they are doing it and where they are going in comparison with a typical high school.

An air of respect pervades each school, respect for individuals – even the youngest and most angular learner – respect for property, respect for the professional needs and individuality of the adult staff. While one sees the differences among youngsters carefully attended to, one notices the absence of rigid streaming based on sets of one-off tests. The school is less about

sorting and more about education. The culture of the school encourages all learners to rise to their full potentials while reducing such self-fulfilling prophecies as “I am a girl and will never take Science”. Respect also plays out in the school’s collective attitude toward youngsters’ families and the neighbourhoods from which they come. The faculty and students and parents engage continually and intently to address the racial, ethnic, cultural, and economic differences that young people bring with them into the common school.

In the staff room, one hears as much or more talk about learners and ideas and teaching as about the personal affairs of individual teachers’ families or local sports teams. One will hear complaints – the work is difficult, many of the learners are distracted, the support of the community uneven – but one senses less cynicism and defeatism than in traditional schools.

The faculty teams for each school have authority there, and the school itself has substantial autonomy within the district. With the delegation of authority comes the frightening reality of responsibility and also the surge of energy released by having substantial control over one’s teaching than is found in most schools. There is more collegiality, more optimism, more articulated stress, and the differences and strains within the school’s adult community and their concerns about their learners emerge in the faculty room and are dealt with there. In sum, as one listens to the teachers’ voices, one senses the school as a whole, most particularly both the attitude of respect for all involved and a commitment that the youngsters must be provoked and coached and supported and pushed to get into the habit of thinking on their own.

A highly blurred line between teachers and administrators is quickly apparent. The principal of the entire operation is the principal teacher, and the team leaders of each separate school, in fact, are principals of small institutions. One senses a collective vision and an understood division of labour. At the heart of this vision is an agreement that it is in constant motion, subject to collective discussion, and once again one hears the hard but constructive edges of debate over what the school should stand for, what it should teach, and most of all what kind of youngsters it should claim as its graduates.

5.5 Conclusion

I began my thesis with the poignant words of G.B. Shaw who likened a traditional school to a prison and, in some cases, to conditions even more cruel than a prison. The vision of the

essential schools which I have quoted and portrayed in the last section provides learners and their teachers with a more humane milieu to grow and develop. Indeed, South African schools will be making the transition from authoritarian systems to ones based upon more democratic principles, where the learners are no longer recipients of knowledge but more active processors of knowledge.

There are wider forces at work causing such changes, such as economic realities, and hence the transition is inevitable. OBE is a means of coping with such global circumstances, and I agree with Victor Hugo, as quoted in Boyd (1992:505), who asserted: "Greater than the tread of mighty armies is an idea whose time has come."

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APPENDICES

APPENDIX A

1) St Sebastian's Questionnaires

- (i) For Personnel
- (ii) For Learners

2) Mtunzini Questionnaires

- (i) For Personnel
- (ii) For Learners

The purpose of the questionnaire

In recent days I have interviewed you and accumulated quite a corpus of data in the process. I would now like to administer a questionnaire to confirm what has already been verbalised. I appreciate the time and effort which you are about to invest. Thank you.

(1). Evaluate each of the following conditions at St Sebastian's as they impact upon your current teaching, according to a 9 point scale:

(a). **Resources and equipment**

Very poor and Scarce resources 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent resources

(b). **Time for lessons**

Very limited time 1.....2.....3.....4.....5.....6.....7.....8.....9 A large amount of time

(c). **Support from colleagues in Science Department**

Very uncooperative Colleagues 1.....2.....3.....4.....5.....6.....7.....8.....9 Very supportive colleagues

(d). **Support from colleagues in other departments**

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent support

(e). **Cooperation from pupils**

No cooperation 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent cooperation

(f). **Physical environment of classroom, e.g. space availability and fixed work benches**

Poor arrangement 1.....2.....3.....4.....5.....6.....7.....8.....9 Most satisfactory

(g). **Support from management**

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent support

(2). **How important are the following factors when judging the success of St Sebastian's as a school?**

(a). **The good matric pass rate of its pupils**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(b). **The success of the 1st XV rugby team**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (c). **A culturally oriented pupil-body, i.e. pupils participate widely in concerts, choir and drama productions**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (d). **The school's ability to produce pupils who cooperate with their peers in a Science class**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (e). **The school's ability to produce pupils who communicate effectively with peers In a Science class**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (f). **The school's ability to foster a democratic learning environment**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (g). **The school's ability to produce critical and creative thinkers**

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

- (3). Rank the following in order of importance by **parents** who may be deciding to send their boys to St Sebastian's. List the number only in the space provided below, e.g. (iii).

- (i). The school's emphasis on sport
- (ii). A wide variety of cultural activities
- (iii). A good matric pass rate of former pupils
- (iv). A strong church-based supportive environment.

Most important _____
↓
Least important _____

- (4). **Your Teaching**

How do you **emphasise** the following in your teaching?

- (a). **The textbook**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

- (b). **Worksheets and photocopied notes**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(c). **Research in the library**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(d). **Open discussions in class about topical issues, e.g. ozone depletion, deforestation, greenhouse effect etc...**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(e). **Clearly formulated experiments on worksheets**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(f). **Experiments where process skills, e.g., hypothesizing, predicting, inferring etc. are emphasized.**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(g). **Teacher controlled discussions and explanations**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(5). **Your experimental work with children in Grade 8**

(a). Consider the experiments which the Grade 8s are doing this year. How many are:

Group work experiments

Teacher demonstrations

Individually performed experiments by pupils

(b). If you were to **mark** a group work experiment, how important are the following to you?

(I). **Accurate results**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(II). **The practical write-up**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(III). **Ability of child to work effectively in a group**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(IV). **Ability of child to gather information about experiment beforehand**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(V). **Ability of child to use process skills in designing his/her own experiment**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(6). **The pupil-population**

Knowing the pupils as well as you do, rank what you think is most important to them choosing from the following options:

1. Winning a cricket match against Kingswood
2. Winning a chessmatch against Kingswood
3. Being a good Christian/Jew
4. Reading an interesting magazine article about Pathfinder's mission on Mars
5. Having a good academic conversation in class about why ice floats on water
6. Scoring 100% for a Science test.

Rank by number only

Most important _____
↓
Least important _____

(7). **Examinations**

Answer each of the following questions as briefly as possible:

- (a). Is St Sebastian's product- or process-oriented learning environment

Product

☐

Process

☐

- (b). What do you see as the advantages of such a system?

- (c). How accurate are St Sebastian's exam/test results for measuring a person's ability?

- (d). What are the purposes of formative assessment?

(e). What are the purposes of portfolio assessment?

(8). Fully transformational Outcomes-Based Education (OBE)

(a). On the following continuum where would you position your colleagues's attitudes in the Science department towards implementing a fully transformational OBE system at St Sebastian's

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Total support

(b). Where would you position your own attitude towards implementing a fully transformational OBE system at St Sebastian's

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Total Support

(c). How much of this perception has been influenced by good teaching sense? Explain.

(d). How much of this perception has been influenced by media coverage? Explain.

(e). Take a guess in deciding how supportive the parents are towards implementing a fully transformational form of OBE at St Sebastian's

Strongly resistant 1.....2.....3.....4.....5.....6.....7.....8.....9 Strongly supportive

(f). List the most prominent obstructions opposing the introduction of fully Transformational OBE at St Sebastian's

(g). List the ways in which St Sebastian's is well suited to introducing OBE:

Grade 3Z Questionnaire

Questionnaire: Suitability of Outcomes -Based Education for the current system at St Andrew's, Grahamstown

General Comment

This questionnaire has been set up to assist me towards understanding the suitability of implementing my Science course at St Sebastian's

I need to know how much time you have to study, what your interests are and what you found most successful or unsuccessful in my Science lessons.

Go through the questionnaire and do what the instructions require of you. Your honesty will help me and may lead to an improved course in the future.

Section I: Sport

- (1). Which two sports did you play in Easter Term before the rugby/hockey season began?
Choose from the list below by marking the correct box with a X as follows:

	Tennis	☒		
Rowing	☐		Triathlon	☐
Cricket	☐		Swimming	☐
Tennis	☐		Squash	☐
Waterpolo	☐			

- (2). What was your **major** sport? _____
- (3). How many days of the week did you play your **major** sport under teacher control?

Mark the right box as follows:

	2	☒	
1	☐	4	☐
2	☐	5	☐
3	☐	6	☐

- (4). How many hours was each major- sport practice session?

1 hour	☐	2 hours	☐	3 hours	☐	Other	☐
--------	--------------------------	---------	--------------------------	---------	--------------------------	-------	--------------------------

- (5). How many matches did you play each week? _____
- (6). How long was each match? _____
- (7). Were there matches on the weekend? _____
- (8). What was your **Minor** sport? _____

(9). How many days of the week did you play your **minor** sport under teacher control?

1 ☐ 2 ☐ 3 ☐

(10). How many hours was each **minor** sport practice session?

$\frac{1}{2}$ hour ☐ 2 hours ☐ 3 hours ☐
1 hour ☐ $\frac{1}{2}$ hours ☐

(11). How many matches did you play each week? _____

(12). How long was each match? _____

(13). Were there matches on the weekend? _____

(14). What is your sport in winter season?

Rugby ☐ Hockey ☐

(15). How many afternoons of the week are there scheduled practice sessions?

1 ☐ 4 ☐
2 ☐ 5 ☐
3 ☐

(16). How long is each practice session?

$\frac{1}{2}$ hour ☐ 2 hours ☐
1 hour ☐ $2\frac{1}{2}$ hours ☐
 $1\frac{1}{2}$ hours ☐ 3 hours ☐

(17). Would you do sport if your teacher never told you to? _____

Explain: _____

Section II: Visits to the Library

(1). How many times a week, on average, did you visit the library with your class teacher?

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

- (2). When in the library, what do your class teachers insist that you do?

3

- (3). Do you have a special library period run by a librarian? _____

What do they teach you or expect from you?

- (4). How many times have you been to the library on your own? _____

- (5). How many books have you read this term?

1	☐	2	☐	3	☐	
4	☐	5	☐	6	☐	Other ☐

- (6). Give the names of three books: _____

- (7). What stops you from reading more books?

- (8). How many hours a week do you spend reading books either because your teachers want you to or by your own choice?

$\frac{1}{2}$ hour	☐	$1\frac{1}{2}$ hours	☐	$2\frac{1}{2}$ hours	☐
1 hour	☐	2 hours	☐	3 hours	☐

- (9). Do you ever use CD-ROM in the library?

YES ☐ NO ☐

If YES Fill Out Parts 10 & 11

- (10). Do you use CD-ROM more than books and magazines?

YES ☐ NO ☐

(11). What is the usual purpose for using CD-ROM?

homework

☐

Interest

☐

Section III: Schoolwork

Science

The following questions are designed to find out what your attitudes and opinions are concerning my Science course.

The method for choosing an option from the selection provided in a table is as follows:

strongly disagree	disagree	I didn't mind them	agree	strongly agree
-------------------	----------	--------------------	------------------	----------------

This means you agree with the statement.

- (1). The readings at the start of the term (e.g. Tribal Warfare & Taxes and Triangles) helped me to better understand Science:

strongly disagree	disagree	I didn't mind them	agree	strongly agree
-------------------	----------	--------------------	-------	----------------

- (2). Mr Wilkinson's explanations of the work, for example mass, volume and density were all generally

poor	fair	airight	good	very good
------	------	---------	------	-----------

Explain referring to specific examples:

(3). The homework which Mr Wilkinson set was:

too easy and boring	just right	difficult, but possible	impossible
---------------------	------------	-------------------------	------------

Explain referring to specific examples:

(4). The experiment demonstrations of Mr Wilkinson, for example, "bail-and-ring" and "ice on water" were:

terrible	poor and confused me	fair, but didn't help me much	good and improved understanding	excellent and helped me a lot
----------	----------------------	-------------------------------	---------------------------------	-------------------------------

(5). The number of experiments which we got to do:

were not enough	could have been more	were sufficient
-----------------	----------------------	-----------------

(6). The experiments which we got to do:

made understanding difficult	neither helped nor confused me	improved understanding
------------------------------	--------------------------------	------------------------

Explain with reference to the experiment: "Density and the processes of Science"

(7). The readings at the end of the term (e.g. "water and density in nature") helped me to better understand the topic of "density".

disagree	I didn't mind them	agree	strongly agree
----------	--------------------	-------	----------------

(8). The test on density which Mr Wilkinson set was:

too difficult	just right	too easy
---------------	------------	----------

Explain: _____

(9). Mr Wilkinson's Science lessons were:

poor	fair	alright	good	very good
------	------	---------	------	-----------

Explain: _____

Section IV: Cultural Activities

(1). Which cultural activities were you involved in?

Debating	☐	School play	☐
Shooting	☐	Cornish Society	☐
School Choir	☐	Alchemists	☐
Astronomers Society	☐	Chess Club	☐
Musical Band	☐	Agricultural Society	☐
Film Society	☐	Philharmonic Society	☐
Wildlife Society	☐	House Play	☐

(2). Write down your first cultural activity: _____

(3). How many times did you meet each week?

1 ☐ 2 ☐ 3 ☐

(4). How long was each practice or meeting?

$\frac{1}{2}$ hour		$\frac{1}{2}$ hours		$2\frac{1}{2}$ hours	
1 hour		2 hours		3 hours	

(5). Write down your second cultural activity: _____

(6). How many times did you meet each week?

1		2		3	
---	----------------------	---	----------------------	---	----------------------

(7). How long was each practice or session?

$\frac{1}{2}$ hour		$\frac{1}{2}$ hours		$2\frac{1}{2}$ hours	
1 hour		2 hours		3 hours	

Section V

Rank (write down from most important to least important) what you think is most important to you in the following list:

1. Winning a cricket match against Graham.
2. Winning a chessmatch against Graham.
3. Being a good Christian/Jew.
4. Reading an interesting magazine article about big game hunting in sub-Saharan Africa.
5. Having a good academic conversation in class about why ice floats on water.
6. Scoring 100% for a Science test.

Rank by number only:

Most important



Least important

Questionnaire for Management & Science Department Personnel

The purpose of the questionnaire

In recent days I have interviewed you and accumulated quite a corpus of data in the process. I would now like to administer a questionnaire to confirm what has already been verbalised. I appreciate the time and effort you are about to invest. Thank you.

(1). Evaluate each of the following conditions at **Mtunzini** as they impact upon your current teaching, according to a 9 point scale:

(A). **Resources and equipment**

Very poor and scarce resources 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent resources

(B). **Time for lessons**

Very limited time 1.....2.....3.....4.....5.....6.....7.....8.....9 A large amount of time

(C). **Support from colleagues in Science Department**

Very uncooperative colleagues 1.....2.....3.....4.....5.....6.....7.....8.....9 Very supportive colleagues

(D). **Support from colleagues in other departments**

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent support

(E). **Cooperation from pupils**

No cooperation 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent cooperation

(F). **Physical environment of classroom, e.g space availability**

Poor arrangement 1.....2.....3.....4.....5.....6.....7.....8.....9 Most satisfactory

(G). **Support from management**

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Excellent support

(2). How important are the following factors when judging the success of Mtunzini as a school?

(A). The good matric pass rate of its learners

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(B). The success of the sports teams

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(C). A culturally oriented pupil-body, i.e. pupils participate widely in concerts, choir and drama productions

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(D). The school's ability to produce pupils who cooperate with their peers in a Science class

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(E). The school's ability to foster a democratic learning environment

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(F). The school's ability to produce pupils who communicate effectively with peers in a Science class

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(G). The school's ability to produce critical and creative thinkers

Unimportant 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(3). Rank the following in order of importance by **parents** who may be deciding to send their children to **Mtunzini**. List the number only in the space provided below, e.g. (iii).

- (i). The school's emphasis on sport
- (ii). A wide variety of cultural activities
- (iii). A good matric pass rate of former learners
- (iv). A church-based supportive environment

Most important _____
 ↓
 Least important _____

(4). **Your teaching**

How do you **emphasise** the following in your teaching?

(A). **The textbook**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(B). **Worksheets and photocopied notes**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(C). **Research in the library**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(D). **Open discussions in class about topical issues, e.g. India's recent nuclear testing programme and its political and environmental consequences.**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(E). **Clearly formulated experiments on worksheets**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(F). **Experiments where process skills, e.g., hypothesizing, predicting, inferring etc. are emphasized.**

No emphasis 1.....2.....3.....4.....5.....6.....7.....8.....9 A lot of emphasis

(5). **Your experimental work with children in Grade 8**(A). **Consider the experiments which you have done with the Grade 8s either this year or in past years. How many are:**

Group work experiments

Teacher demonstrations

Individually performed experiments by learners

(B). **If you were to **mark** a group work experiment, how important are the following to you?**(I). **Accurate results**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(II). **The practical write-up**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(III). **Ability of learner to work effectively in a group**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(IV). **Ability of learner to gather information about experiment beforehand**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(V). **Ability of learner to use process skills in designing his/her own experiment**

Not important 1.....2.....3.....4.....5.....6.....7.....8.....9 Very important

(6). The learner-population

Knowing the learners as well as you do, rank what you think is most important to them choosing from the following options:

1. Winning a football match against a rival school
2. Winning a chessmatch against a rival school
3. Being a good Christian/ Moslem
4. Reading an interesting magazine article about Pathfinder's mission on Mars
5. Having a good academic conversation in class about why a globe shines in a electrical circuit
6. Scoring 100% for a Science test.

Rank by number only

Most important _____
 ↓

 Least important _____

(7). Examinations

Answer each of the following questions as briefly as possible:

- (A). Is Mtunzini a product- or process-oriented learning environment

Product ☐ Process ☐

- (B). What do you see as the advantages of such a system?

- (C). How accurate are Mtunzini's exam/test results for measuring a person's academic ability?

- (D). What are the purposes of formative assessment?

- (E). What are the purposes of portfolio assessment?

- (8). **Fully transformational Outcomes-based Education (OBE)**

- (A). On the following continuum where would you position your colleagues's attitudes in the Science department towards implementing a fully transformational OBE system at Mtunzini ?

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Total support

- (B). Where would you position your own attitude towards implementing a fully transformational OBE system at Mtunzini ?

No support 1.....2.....3.....4.....5.....6.....7.....8.....9 Total support

- (C). How much of this perception has been influenced by good teaching sense? Explain.

- (D). How much of this perception has been influenced by media coverage? Explain.

- (E). Take a guess in deciding how supportive the parents are towards implementing a fully transformational form of OBE at Mtunzini .

Strongly resistant 1.....2.....3.....4.....5.....6.....7.....8.....9 Strongly supportive

- (F). List the most prominent obstructions opposing the introduction of fully transformational OBE at Mtunzini :

(G). List the ways in which Mtunzini is well suited to introducing OBE:

Thank you for your cooperation.

Grade 8g Questionnaire

Questionnaire: Suitability of Outcomes-Based Education for the current system at Nombulelo Secondary School, Grahamstown

General Comment

This questionnaire has been set up to assist me towards understanding the suitability of implementing my Science course at Mtunzini

I need to know what your home-living circumstances are, what interests you and what you found most successful or unsuccessful in my Science lessons.

Go through the questionnaire and do what the instructions require of you. Your honesty will help me and may lead to an improved course in the future.

Section I: Your home-living conditions

- (1). When you come to school, have you had breakfast?
Choose from the possibilities below by marking the correct box with a X as follows:

For example: YES ☒

YES ☐ NO ☐

- (2). When at school do you have lunch at breaktime?

YES ☐ NO ☐

- (3). How far do you live from school?

$\frac{1}{2}$ km - 1km ☐	1km - 2km ☐	2km-3km ☐
3km - 4km ☐	4km - 5km ☐	5km - 10km ☐
10km - 15km ☐	15km - 20km ☐	Other ☐

- (4). What transport do you use in getting to school and then going home each day?

Walk ☐ Bicycle ☐ Parents' car ☐ Taxi ☐

- (5). Do you have your own room to study in? YES ☐ NO ☐

If NO, answer the next question:

- (6). Who else lives in your room? _____

- (7). Do you have electric lighting in your room to study by?

YES ☐ NO ☐

If NO, answer the next question:

- (8). What sort of lighting do you have?

Candle light ☐ Paraffin lamp ☐ Torch light ☐
Other

Section II: Schoolwork

(A). General

- (1). When in class, what things do you do most? Give each statement a mark out of 10 where:

10 = done a lot

0 = not done at all

work from textbooks	☐
work in a group to solve a hard problem	☐
copy down notes from blackboard or screen	☐
listen to the teacher	☐
visit the library to find out more about a section of the work	

- (2). How important is your teacher in your education?

Not important ☐ Needed ☐ Very important ☐

- (3). How important is doing extra reading (i.e. reading not to be found in textbooks) when studying for class tests.

Not important ☐ Done sometimes ☐ Done most of the time ☐

- (4). Do the teachers at Mtunzini have a good attitude to their work and give you a lot of help? Mark the best description below

Poor ☐ Fair ☐ Good ☐ Very Good ☐ Excellent ☐

- (5). How many periods a week, on average, do you **NOT** have lessons because the teacher is **NOT** at school.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐

- (6). When a teacher is absent, what do you do for that period?

Play cricket, football or rounders ☐

Sit and talk with friends about things outside of school ☐

catch up with homework or project work ☐

leave the school and go home for a while ☐

- (7). How important is doing well at school to your parents?

Not important ☐ Of some interest ☐ Very important ☐

(B). Science

The following questions are designed to find out what your attitudes and opinions are concerning my Science course.

The method for choosing an option from the table below is:

strongly disagree	disagree	I didn't mind them	agree	strongly agree
-------------------	---------------------	--------------------	-------	----------------

- (1). The readings at the end of the term (e.g. Man bites Shark!) helped me to better understand Science:

strongly disagree	disagree	I didn't mind them	agree	strongly agree
-------------------	----------	--------------------	-------	----------------

- (2). Mr Wilkinson's explanations of the work, for example, why a globe shines, were all generally

Poor	Fair	Alright	Good	Very Good
------	------	---------	------	-----------

Explain referring to specific examples:

- (3). The homework which Mr Wilkinson set was:

too easy and boring	just right	difficult, but possible	impossible
---------------------	------------	-------------------------	------------

Explain referring to specific examples:

- (4). The experimental demonstrations of Mr Wilkinson, for example, "magnetic effect of an electric current" were:

terrible	poor and confused me	fair, but didn't help me much	good and improved understanding	excellent and helped me a lot
----------	----------------------	-------------------------------	---------------------------------	-------------------------------

- (5). The number of experiments which we got to do:

were not enough	could have been more	were sufficient
-----------------	----------------------	-----------------

- (6). The experiments which we got to do:

made understanding difficult	neither helped nor confused me	improved understanding
------------------------------	--------------------------------	------------------------

Explain with reference to the circuit board experiments you did.

- (7). The test on electricity which Mr Wilkinson set was:

too difficult	just right	too easy
---------------	------------	----------

Explain: _____

- (8). Mr Wilkinson's Science lessons were:

poor	fair	alright	good	very good
------	------	---------	------	-----------

Explain: _____

(C). **Science Experiments**

Explain briefly about the questions below:

- (1). Does everyone in your group do something with the apparatus in setting up the electric experiment.

- (2). Is everyone's opinion (i.e. what you have to say) heard and talked about among people in your group before carrying on with the experiment?

- (3). Are you happy with the space in the classroom in which you have to move around in while doing your experiments?
-

- 4). In setting up your "telegraph sets" or working on your oral presentations which things did you find the hardest to do?

- (I). Find the apparatus or visual aid material needed
- (II). Work in a group to finish the job
- (III). Give your oral presentation

Rank (write down from hardest to easiest) by number only.

Hardest _____
↓
Easiest _____

(D). **Final Summary**

Rank what you think is most important in the following list from most to least important.

- (1). Winning a cricket match against a rival school
- (2). Winning a chessmatch against a rival school
- (3). Being a good Christian/Moslem
- (4). Reading an interesting magazine article about water shortages
- (5). Having a good academic conversation in class about why a globe shines when connected in a circuit.
- (6). Scoring 100% for a Science Test.

Rank by number only:

Most important



Least important

Thank you for your cooperation

APPENDIX B

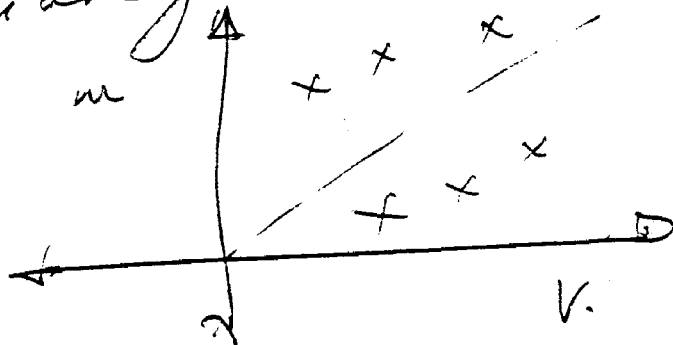
Example of a Field Note

17 March 1998 (Tuesday) 84: Mr. Re^hissan

Sinker Float Continuation. ^{Person} Start at 2:40.

Mr. ~~Re~~ began lesson by asking kids to plot pts on Cartesian plane — This procedure he has already covered in class beforehand.

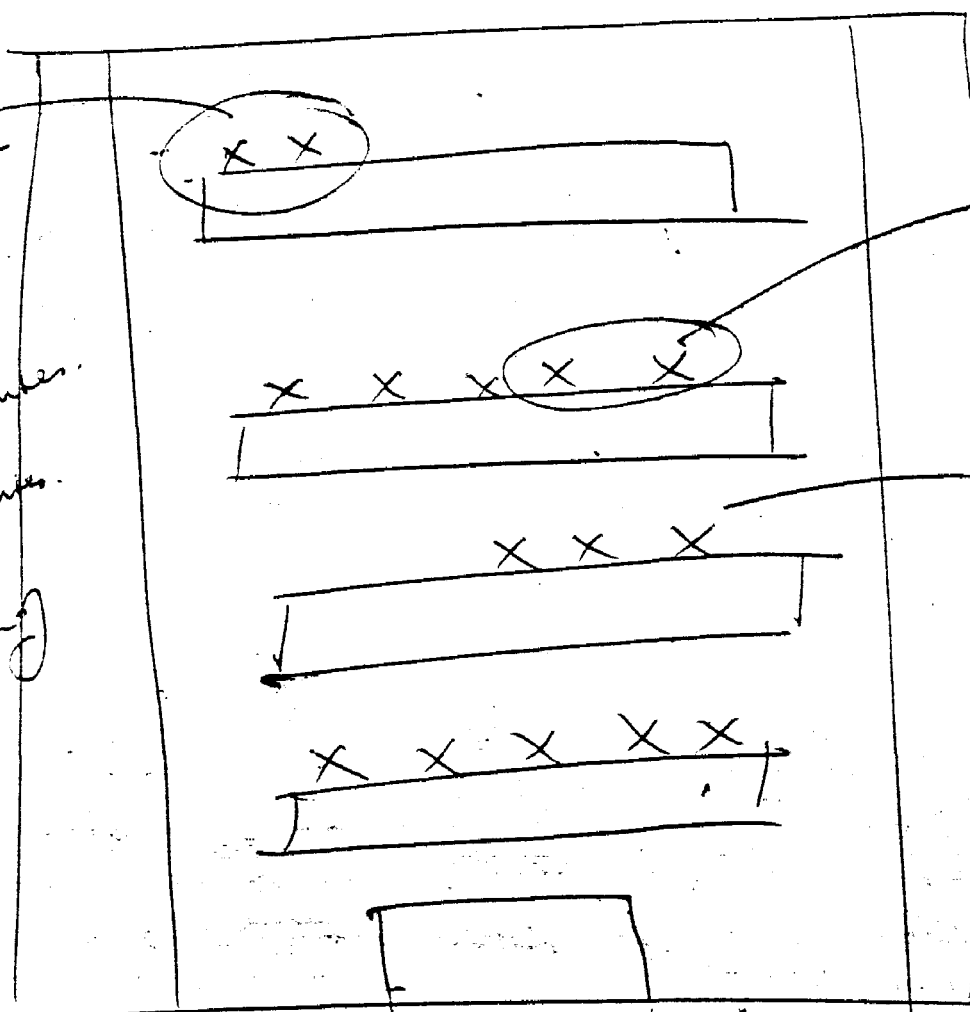
The boys are given time to plot their graphs:



At 3:00 pm - 20 minutes
kids at back
of class
ask ⑦ about
pts.

Boys seem to
be restless
at 3:05 pm -
25 minutes.

At 3:03 pm - 23 minutes
boys are
asked to
draw a
sk line to graph.

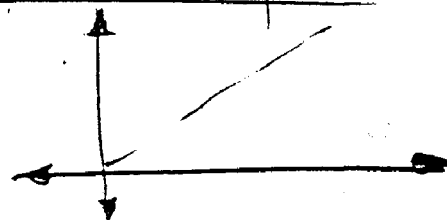


Boys are
engaged
at 3:02 pm
playing around
seen to
make
pooping noise
maybe to be
heard on tape

Stark boy
pulling his
shirt +
talking to
guy behind.
Rob seems
intimidated in
dealing with
kids -
maybe it is
bit.

Boys have
nobility.

⑦ goes to board and writes:



APPENDIX C

Grade 8Z

Course Notes for St Sebastian's

Assignment: Science & Scientists

General Comment

The purpose of this assignment is to allow you as Grade 8 learners to critically think about Science and about those people who engage in Science as an activity. The reference which I consulted for this assignment was

Reiss, M.J. (1993). *Science education for a pluralist society*. Open University Press. Philadelphia.

Instructions

- 1) Complete each question before reading or continuing with the next question.
- 2) Do not discard your answer sheets when the session is complete. You will need it for the class discussion which is to follow and I need it for my thesis!

Assignment 1

Make a free-hand drawing of a scientist at work. You must include as much detail as possible; illustrating *where* the scientist is working and *what* the scientist is doing.

Assignment 2

Describe in no more than a page what you understand the subject "Science" to involve.

Assignment 3

Read an extract from the Reiss article provided before attempting to answer its corresponding question:

3(i)

Who are scientists?

Some months ago, I happened to see a new set of postage stamps produced in the UK, titled 'Scientific achievements' (issued 5 March 1991). It's worth spending a few moments imagining what you might expect (or hope!) to see on these stamps. Well, whatever you thought, the Royal Mail produced four stamps under the heading 'Scientific achievements' with the captions 'Faraday - Electricity', 'Babbage - Computer', 'Radar - Watson-Watt' and 'Jet Engine - Whittle'.

Reiss 1993:17)

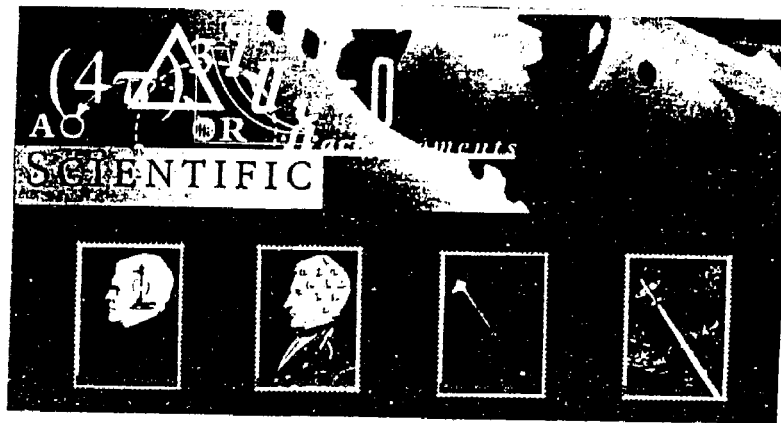


Fig. 2.1 Presentation pack of UK postage stamps issued on 5 March 1991 under the title 'Scientific achievements'.

Reiss (1993:18)

Reiss (1993:17) describes the stamps provided by the Royal mail. Where does the popular perception lie with the general public, ie who, in their opinion "does science"? Do you as boys agree with their standpoint that Science is exclusively for males (ie men) only? Argue your case.

3(ii) Read the extract concerning Jane Goodall.

When Jane Goodall first arrived to study the chimpanzees on the banks of Lake Tanganyika, the game warden who took her round made a mental note that she wouldn't last more than six weeks. She has stayed for over thirty years,

producing the definitive accounts of chimpanzee social organization and behaviour in her fascinating and moving books *In the Shadow of Man* (van Lawick-Goodall, 1971) and *The Chimpanzees of Gombe: Patterns of Behavior* (Goodall, 1986).

An important point about Jane Goodall is that she had no formal training in ethology (the science of animal behaviour), having trained as a secretary after leaving school. As she herself wrote 'I was, of course, completely unqualified to undertake a scientific study of animal behaviour' (van Lawick-Goodall, 1971: 20). However, she spent some time with the celebrated palaeontologist Louis Leakey and his wife, Mary, on one of their annual expeditions to Olduvai Gorge on the Serengeti plains. Louis Leakey became convinced that Goodall was the person he had been looking for for twenty years – someone who was so fascinated by animals and their behaviour that they would be happy to spend at least two years studying chimpanzees in the wild. Leakey was particularly interested in the chimpanzees on the shore of Lake Tanganyika as the remains of prehistoric people had often been found on lake shores, and he thought it possible that an understanding of chimpanzee behaviour today might shed light on the behaviour of our Stone Age ancestors.

Goodall couldn't believe that Leakey was giving her the chance to do what she most wanted to do – watch chimpanzees in their natural habitat. She felt that her lack of training would disqualify her. But, as she later wrote:

Louis, however, knew exactly what he was doing. Not only did he feel that a university training was unnecessary, but even that in some ways it might have been disadvantageous. He wanted someone with a mind uncluttered and unbiased by theory who would make the study for no other reason than a real desire for knowledge; and, in addition, someone with a sympathetic understanding of animal behaviour.

(van Lawick-Goodall, 1971: 20)

Now the point, of course, is not that Jane Goodall could approach chimpanzees with a mind 'uncluttered and unbiased by theory' but that the clutter and theory in her mind was crucially distinct from that in someone who emerged from a university

course in ethology. In the 1960s one of the great heresies of academic ethology was to be anthropomorphic – to treat non-humans as if they had human attributes and feelings. That is precisely what Jane Goodall did, and it allowed fundamentally new insights into chimpanzee behaviour. A flavour of Jane Goodall's approach can be obtained by reading the following quote:

One day, when Flo was fishing for termites, it became obvious that Figan and Fifi, who had been eating termites at the same heap, were getting restless and wanted to go. But old Flo, who had already fished for two hours, and who was herself only getting about two termites every five minutes, showed no signs of stopping. Being an old female, it was possible that she might continue for another hour at least. Several times Figan had set off resolutely along the track leading to the stream, but on each occasion, after repeatedly looking back at Flo, he had given up and returned to wait for his mother.

Flint, too young to mind where he was, potted about on the heap, occasionally dabbling at a termite. Suddenly Figan got up again and this time approached Flint. Adopting the posture of a mother who signals her infant to climb on to her back, Figan bent one leg and reached back his hand to Flint, uttering a soft pleading whimper. Flint tottered up to him at once, and Figan, still whimpering, put his hand under Flint and gently pushed him on his back. Once Flint was safely aboard, Figan, with another quick glance at Flo, set off rapidly along the track. A moment later Flo discarded her tool and followed.

(van Lawick-Goodall, 1971: 114-5)

Other writers at the time did not give names to their animals; nor did they use language like 'getting restless', 'wanted to go', 'set off resolutely' and 'potted about'; nor did they impute to their subjects the ability consciously to manipulate one another.

Apart from her lack of formal training, there is another factor about Jane Goodall that may well be significant. She is a woman. The three longest-running studies on animal behaviour have all been carried out by women: Jane Goodall on chimpanzees (1960 to present); Dian Fossey on gorillas (1966 to 1985 when she was murdered, probably

because of her dedication to the gorillas (Mowat, 1971); and Fiona Guinness on red deer (1972 to present (see Clutton-Brock *et al.*, 1982)).

Would you say that Jane Goodall is a scientist bearing in mind that she is a woman and a former secretary? What can you conclude about yourselves? Are you scientists? Support your argument with some reasoning.

3(iii) When I was studying Science at school my teacher said that Physics is a precise science. Years later I thought about this statement and I interpreted it to mean that it accurately describes reality as it is. Now read Reiss (1993:20-21):

Scientists approach their topics of study with preconceptions. There is no such thing as an impartial observation. In the classroom this is seen to be the case every time a group of pupils is asked, for the first time, to draw some cells or sulphur crystals under the microscope. It isn't possible until you know what to draw. Unless you know that a leaf of pondweed consists of numerous small brick-like structures, all you *can* see is a mass of green with lines and occasional air bubbles. In the same way, the first time the German artist Dürer saw a rhinoceros, he drew what, by his normal standards, could be described as a fat armour-plated horse (Fig. 2.4). To expect pupils to draw regular epidermal cells the first time they see them is to expect more of them than Dürer could manage.

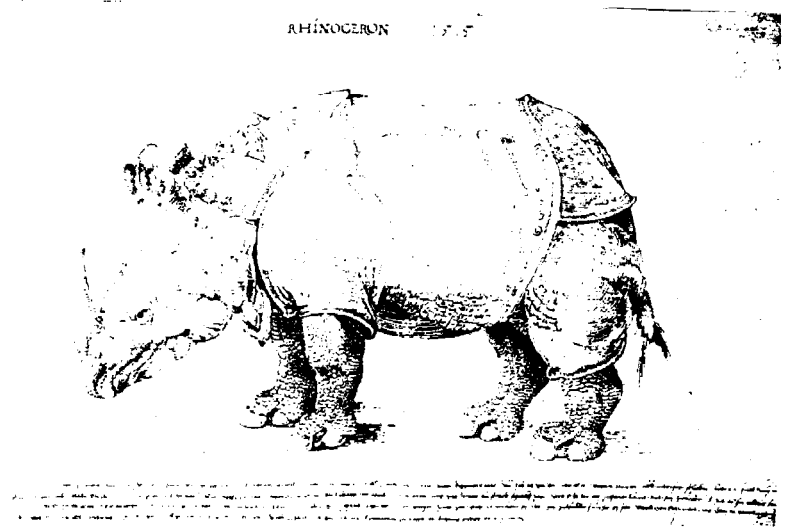


Fig. 2.4 Albrecht Dürer's rhinoceros. Pen and Ink, 1515.

From the article, do you think my science teacher was telling the truth? Does Physics truly reflect external circumstances? ie is what we see really the way things are?

This may be deeply philosophical, but to help you decide on a response consider a classic story of the courtship of Sticklebacks recorded by Tinbergen (1937) and Tor Pelkwijk (1951).

Tinbergen & Tor Pelkewijk's account

In spring, male sticklebacks acquire territories from which they chase away intruders of either sex. During this period males acquire red bellies. This redness makes males particularly likely to chase away other males. Tinbergen found that a realistically shaped but non-red model provoked little interest, whereas extremely crude models painted red on their lower surfaces provoked strong aggression from the territorial male. The male finishes building a nest and now becomes interested in females swollen with eggs. When a female appears he swims towards her in a curious zig-zag fashion (the zig-zag dance). When she sees him the female responds by swimming towards him with her head and tail turned upwards, thereby displaying her swollen abdomen. The male then leads the female and shows her his nest entrance by poking it with his snout. She enters his nest and the male gives her rump several prods with a trembling motion, and this stimulates her to lay eggs. When she has discharged her eggs, she leaves the nest and the male enters it, ejaculates over the eggs and fertilises them. He then chases the female away. Altogether he may mate with as many as five different females. Having fertilised a certain number of clutches, the male loses his readiness to court females. Instead he begins regular ventilation of the eggs by fanning them. Fanning serves to provide the eggs with oxygen and continues until they hatch.

This elegant story is backed by a fifteen-minute film made by Oxford Scientific Films. Notice how the male stickleback is at the centre of the stage, with a crowd of passive females waiting around to be directed and prodded. Recent studies, however, have significantly changed the story (Li and Owings, 1978; Ridley and Rechten, 1981; Rowland, 1982; Reiss, 1984).

For our purposes the work done by Li and Owings is most significant. The crucial factor in Li and Owings' work was that, unlike previous researchers, they spent as much time watching female as male sticklebacks. Furthermore, before individuals of either sex were introduced to individuals of the other sex, the sexes were sexually segregated in groups of six. This enabled Li and Owings to determine female-female interactions as well as

male-male interactions. Their results contrast with the popular notion that female sticklebacks are relatively passive participants in reproduction.

Female sticklebacks averaged 50 per cent *more* aggressive encounters per hour in the all-female group than the males did in the all-male groups. The lesser aggression of the males was not due to any abnormal behaviour on their part: the density of males used was that recommended by previous researchers and males set up and defended territories, as usual, in the experiments. In the all-female groups, females were kept at the same density as males had been. Some females defended territories, others did not. On three occasions females actually lost their eggs. This was observed twice. On each occasion a more dominant female

poked or squashed a more subordinate female, and repeated pressure led to the two subordinate females prematurely shedding their eggs.

Li and Owings also studied groups consisting of six females and six males. Female-female interactions were also important in this situation. On three occasions a subordinate female accepted a courting male before the dominant. Each time the dominant disrupted courtship. On the two occasions that a subordinate female attempted to disrupt courtship by a dominant female, the attempts failed.

Reiss (1993:73)

Are the two sets of authors interpreting the observed happenings in the same way? In two sentences describe the bias inherent in Tinbergen's and Tor Pelkewijk's observations.

Reiss concludes with the following:

... a scientist's *perceptions* of the natural world, as well as her interpretations, come through her senses, herself as a person and her culture. What is of significance for science education is that there can be no single, universal, acultural science. Rather, every sort of science is an ethnoscience.

My own conclusion and understanding of Science. (You need not necessarily accept what I am saying:

A person (or any cultural background) may perceive the natural world through his/her senses. For example, taste, smell, sight etc., but once the so-called "facts" are to hand, interpretation follows. It is in the process of interpretation that people of different culture, ages or gender

will differ. This should become clear with the stickleback example or the Dürer painting of a rhino as quoted earlier. The conclusion here is that there can be no single, universal, acultural science (a science separate from culture).

Science must therefore be seen as a collection of ethnosciences.

In the course which follows, you will have the opportunity to study how Science & Technology has been utilised in other cultures. These foreign cultures are also worthy of respect, since they represent a unique and different way to interpret the natural world.

Reading of Articles

Is science good or bad for society?

1) *Specific Outcome for assignment concerning the article: Tribal Warfare:*

After reading an article, learners must be able to state the ways in which European culture, with its superior technology, influenced the indigenous Indian culture of the Americas – socially and politically.

Assessment Criterion: (During feedback you will be expected to meet certain criteria in the work you deliver).

Learners must illustrate how Science and Technology influences culture.

2) *Specific Outcome for assignment concerning the article: Tribal Warfare:*

After reading an article, learners must explain in written form what European presence, with their highly developed scientific culture, meant for the socio-economic development of the Indian.

Assessment Criteria

- 1) Evidence is provided of how Science & Technology are used in society.
- 2) The way in which scientific and technological developments have changed the lives of people is analysed.
- 3) Roles and consequences of Science in Society are communicated.

Preamble

We are all very familiar with some, of what seems to us, fairly universal symbols of our western lifestyle and culture such as: expensive motor vehicles, *consumer goods*, designer clothing, computers, etc.

However, western influence, with its superior technology, is perceived by many social *anthropologists* to have been detrimental to the indigenous communities of The New World in colonial times.

In the first article, I have selected a few extracts from a Scientific American article entitled *Tribal Warfare*, by R.B. Ferguson. These extracts reveal the negative impact which Science & Technology have had on primitive societies.

In the second article, entitled *Taxes & Triangles* I have presented you with an entire reading concerning ways in which the Egyptians in ancient times used Mathematics to build their pyramids. This article explains how a different society uses the Mathematical Science to promote their culture.

When reading these extracts mark important points in the margins as these will help you to understand the article a little better. After your reading, there are a few questions to see if you can demonstrate the outcomes indicated earlier. Enjoy the articles for they have been selected for your reading pleasure.

Article 1 : TRIBAL WARFARE by R.B. Ferguson

Extract 1

On the sixth day of January 1493, Christopher Columbus began his voyage back from the New World, leaving 38 of his crew on the island of Hispaniola. Their settlement, Villa de la Navidad, was near the village of the Taino chief, Guacanagari, who Columbus said "was proud to call me, and to treat me as, a brother." Columbus was convinced of the peaceful character of the local Indians.

But when he returned less than a year later, the men of Villa de la Navidad were dead. The settlement and block-house had been destroyed. Guacanagari blamed the destruction on more powerful chiefs who lived inland, and Columbus soon witnessed their continuing attacks on the villages of Guacanagari. But his crew also found the possessions of the dead Spaniards, including a ship's anchor, which Columbus believed would not have been bartered, concealed in the houses of Guacanagari's people. Columbus never discovered what actually happened.

The explorers and conquerors who followed Columbus often dwelt on lurid stories of unbridled native violence. When the philosopher Thomas Hobbes wrote in 1651 of the primeval war of "every man against every man," he observed that "the savage people in many places of America...live at this day in that brutish manner." Accepted wisdom even now holds that "primitive" cultures are typically at war and that the primary military effect of contact with the West

is the suppression of ongoing combat. In fact, the initial effect of European colonialism has generally been quite the opposite. Contact has invariably transformed war patterns, very frequently intensified war and not uncommonly generated war among groups who previously had lived in peace. Many, perhaps most, recorded wars involving tribal peoples can be directly attributed to the circumstances of Western contact.

Question 1:

When *Europeans* arrived amongst the local native inhabitants, what did they cause?

Extract 2

Anthropologists have identified three major causes of social change that can destabilize the tribal zone: diseases introduced by settlers, transformation of ecosystems by alien animals and plants, and changes in the way of life made

possible by new goods and technologies. There is much debate about the extent of Native American deaths from new diseases before face-to-face contact with Europeans, but there is no question that massive losses followed quickly on the establishment of missions, forts and trading posts. Frequently these first epidemics were interpreted as a result of witchcraft by local enemies, and aggressive retaliation against presumed culprits ensued. More generally, for groups whose society, economy and politics all rest on a base of kinship, the sudden loss of a third or half of a population is catastrophic - perhaps even more destabilizing than was the Black Death in Europe.

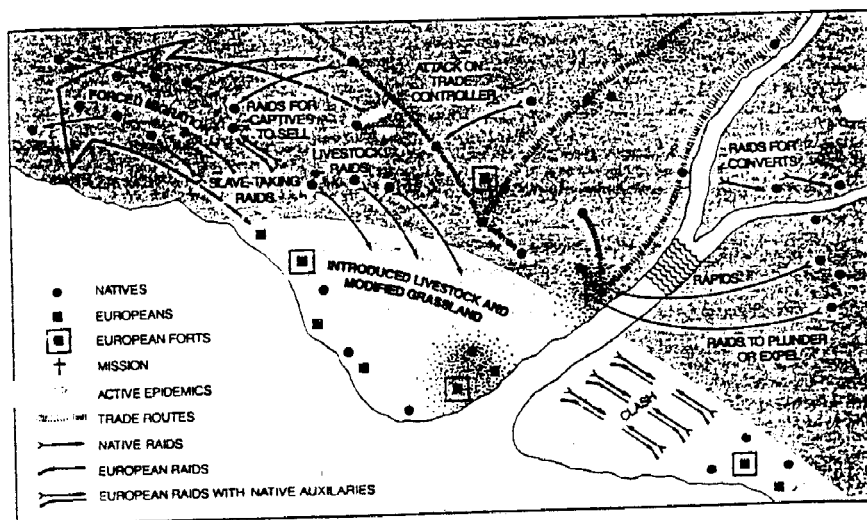
Ecological transformation often preceded the European advance as plants and animals introduced by colonists began to spread by themselves. In some cases, these changes were so widespread that it is difficult to assess what the natural environment was like in places such as New England before 1500. As the natural world changed, so did the interaction between native peoples and that world. This change often revolutionized both the organization of work and social arrangements built on that organization.

Trade in manufactured goods has dominated the interaction of states and their nonstate neighbors since the time of Mesopotamia, but industrial production puts European expansion in a class by itself. Steel tools, for example, are several times more efficient

than are stone implements. The acquisition of axes and machetes enabled many Amazonian groups to expand their forest gardens and to begin production of manioc for trade with Brazilian woodsmen.

Question 2:

Name *three* causes of social change brought about by Western involvement which upset the peaceful existence of the Indians. Consider the map of the tribal zone when developing your thinking.



TRIBAL ZONE is a region extending outward from state boundaries in which the life of tribal groups is disrupted. It is often marked by war, epidemic and ecological change. This

zone is the scene both of direct conflicts between settlers and natives and of hostilities between native groups fleeing state influence or competing for access to trade groups.

Extract 3:

This type of reaction was by no means automatic: generally Europeans were well received, until their predatory behavior became intolerable. Nor was colonial victory in battle assured, especially in the early centuries. Ultimately, however, the ability of states to reinforce their troops from overseas, skillful use of a divide-and-rule strategy, readiness to violate local conventions of war, and technology and military organization led to the defeat of indigenous forces.

Question 3:

What key factors were involved in bringing down native people by the Europeans?

Paraphrase:

The article goes on to explain the various types of warfare which were waged against the Indian. The one was western troops against the Indian. The second was Indian against Indian where one tribe received support from the Europeans. The third was Indian versus Indian; but brought about by competition over European goods or by certain tribes fleeing from Europeans and attacking other tribes beyond the tribal zone.

These events took place in South America. The situation was not that different in North America.

Extract 4:

North America saw similar reorientations of warfare. Probably the best-known case is that of the Great Plains tribes. The introduction of horses and guns transformed their entire way of life, and the subsequent intertribal conflicts were closely linked to this continuing upheaval. Encroaching settlements and the growth of trade in buffalo pelts stimulated competition for buffalo rangeland. Raiding for horses contributed to a constant state of war, and peoples such as the Blackfoot and Cheyenne relied on force to preserve their monopolistic access to Western traders.

Question 4:

Name two factors introduced to North America by the Europeans which changed the way of life for the Great Plains Indians.

These two commodities may be seen as a major step forward in the advancement of the technological and scientific development of the local Indians. They were highly sought after and just like in South America, upheavals were to follow.

Extract 5:

In the Pacific Northwest, groups such as the Kwakiutl, Haida and Tsimshian had established a centuries-old pattern in which residents of localities with few resources raided those who controlled

major salmon rivers and other prime-fishing grounds. These hostilities subsided after European contact, as epidemics killed a third or more of the native population. The intensity of war, however, increased as the development of a fur trade incited battles to control the trade. In addition, the growing wealth of some successful tribes stimulated a local demand for slaves. Slave raiding intensified as some local groups found slaves to be the only commodity they could barter for the firearms they needed for self-defense.

Question 5:

In a few words describe what European presence meant for the socio-economic development of the Indians in the Pacific Northwest.

Paraphrase:

The author goes on to explain the influences of Europeans on the Yanomami tribe in Brazilian highlands near Venezuela. Read extract 6.

By examining all available reports of war or peace among all Yanomami from the early 1800s to the 1980s, I have found that in the overwhelming majority of cases, instances of war followed abruptly on some significant change in the Western presence: either a new

penetration, a withdrawal or a change in location. Constancy in the presence or absence of Westerners is usually accompanied by peace.

Although many factors are involved in this association, access to Western manufactured goods, especially steel tools, has proved crucial to explaining the actual patterns of combat. The Yanomami had steel tools roughly 10 times as efficient as stone axes. They

rapidly become necessities for many basic subsistence tasks, such as clearing gardens and gathering firewood.

The Yanomami place extraordinary value on these tools and on other Western manufactured goods used for utilitarian and ornamental purposes. These items are scarce and unequally available. The Yanomami have made hazardous treks and repeatedly relocated villages in their effort to obtain better access to suppliers of Western goods.

Although the Yanomami sometimes raided Western settlements or other villages to obtain goods, plundering is a risky, short-term solution. It is

far better to establish a position that allows access to a regular source of goods either by moving the village along a trade route or, even better, by settling next to a mission or some other Western outpost. A powerful group in such a location can obtain a relative abundance of new Western trade goods. Furthermore, a group can derive great benefits by acting as monopolistic middlemen in trade to more remote villages.

Such a group often trades Western goods after they have been worn down by use. In return, they receive a wide variety of valuable local products, such as spun cotton, woven hammocks, bows, quivers, curare-tipped arrows, dogs and food. They also gain an advantage in the intermarriage between villages. Remote vil-

Question 6:

Summarise how Science has influenced the culture of these Natives economically, socially and politically.

Final Assignment:

Form a group with three or four of your co-learners and collectively compile a paragraph summarising how Science & Technology intervened in the interaction between European culture and Native American Indian culture in colonial times.

Should you wish to read the unedited article (which I strongly advise) then consult the following:

Ferguson, R.B. (1992). *Tribal Warfare*. Scientific American, 266 (1): 90-95.

Article 2 : TAXES AND TRIANGLES by L. Hogben

In the article “taxes and triangles” you must demonstrate the attainment of two outcomes:

Specific Outcome:

- 1) The learner must be able to extract information from an article and apply this information to solve particular mathematical problems.
- 2) The learner must be able to describe in his own words particular scientific methods used by the Egyptians.

Assessment Criteria:

Learners show work in which:

- (i) problems are identified,
- (ii) relevant information is gathered,
- (iii) relevant scientific knowledge is selected,
- (iv) relevant scientific skills are selected,
- (v) the problem is re-evaluated,
- (vi) innovative options are generated,
- (vii) decisions are made and
- (viii) a possible plan of action is communicated.

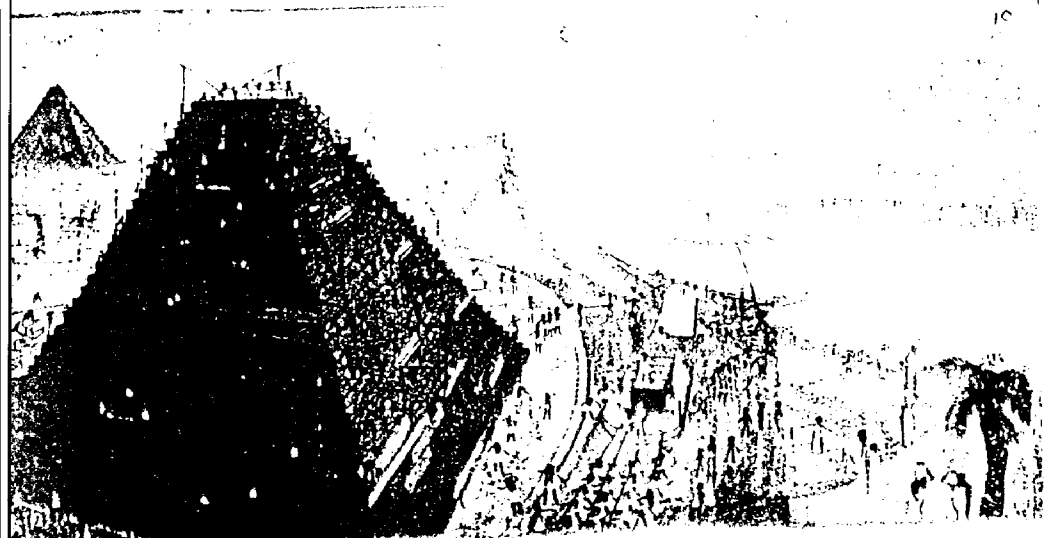
Specific Outcome

The learner must gather information from literary-resource books to answer questions about Egyptian culture and use of Science in their culture.

Assessment Criterion

Learner to illustrate how Science influences cultural factors.

Read the article “Taxes and Triangles” and then attempt the assignments which follow. The idea here is to locate the relevant passage in the text before working and applying innovative solutions to problems. Remember, I stress that you must use your own words when supplying answers, for this demonstrates understanding. There is no sense in merely copying paragraphs mindlessly from the text.



Taxes and Triangles

THE PRIESTS of early Egypt became the most powerful men in the land. It was they who fixed the many holy days—days when the feasts of the full moon or of the midsummer sun were to be held, days when animals sacred to certain star clusters were to be sacrificed, days when offerings were to be made to the gods of the river. It was they, too, who ordered the building of great temples, which they also used as observatories, and of the mighty pyramids, which served as the tombs for their rulers, the Pharaohs.

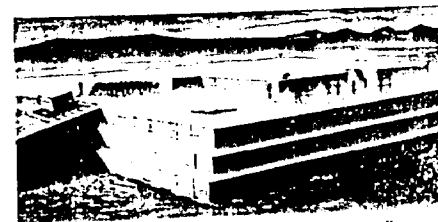
To erect such stupendous buildings, the architects of Egypt had to know how to make some kind of ground plan, how to level the edges of stone blocks, how to haul them up from the ground, and how to set them fairly and squarely in position. In learning all this, the pyramid architects were making practical discoveries in the art of measurement, or as we now say, geometry.

The first ground plans, forerunners of our own blueprints, were probably drawn on clay, simple diagrams to show the shape of the finished building. Those who made them had indeed learned that two things—a drawing and a building—may be of quite different size but of exactly the same shape. So what is true about the shape of one is also true about the shape of the other.

When the ground plan was complete, men with hoes tilled off a stretch of land ready for the masons to begin work. There were as yet neither wheeled vehicles nor good roads. Carcases of heavy building materials, consisting mainly of stone blocks weighing one or two tons, came as near to the site as possible along the River Nile. By boat,

Each block of stone had to be cut to shape. First the rough edges were knocked off with lumps of flint. Next the surfaces were levelled with metal chisels and bell-shaped wooden mallets. Last of all the whole block was smoothed by rubbing with a rough stone tool. Every corner had to be tested with a mason's square, or set-square, to make sure it was a true right-angle.

Then an enormous layer of blocks was laid to form the base of the pyramid. On this a second layer was built, slightly smaller and exactly in the middle of the first. Layer after layer was added in the same way so that all four sides of the finished pyramid would taper equally and meet neatly at the top. To check that it was upright, the edge of each had to be tested with a weight hanging from a string. Earth was piled up the step-like edges to make a sloping road over which the blocks were hauled on sledges with rollers beneath them.



Heavy blocks were hauled up sand ramps on sledges, over rollers.

Perhaps the hardest problem was to make the base of the pyramid really square. The smallest error in fixing the angle at any corner would have thrown the whole building out of shape. Although the builders left no records, we may guess how they would do this.

They might mark out a long straight line, by stretching a cord between two pegs stuck in the ground. Then to each peg they would tie an equal



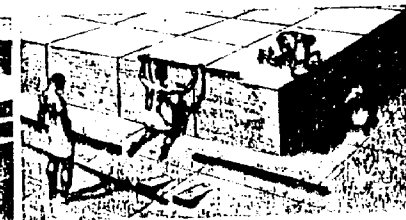
One false angle at base would ruin the shape. Right angles can be made by drawing equal arcs from any two points on a straight line, and joining them with the arcs cross.



Scale plans were drawn on clay tablets before building began.

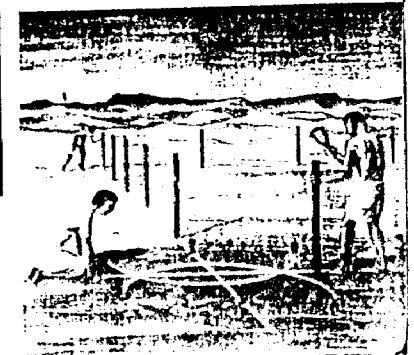


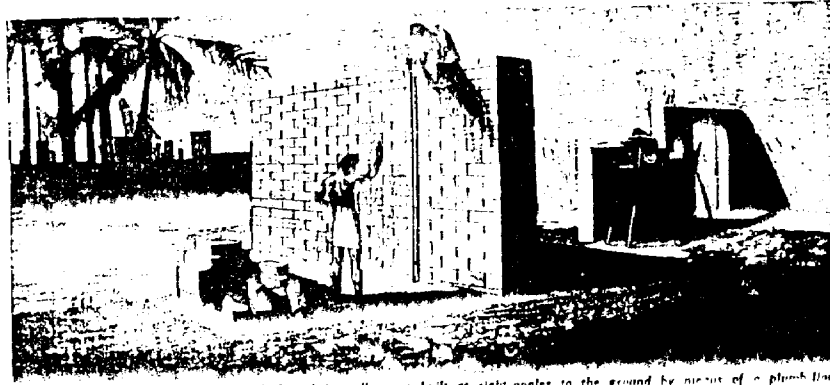
Each block was shaped and corner tested with mason's square.



Plumb-line checked that the blocks were set exactly upright.

length of string, more than half as long as the line they had drawn. By keeping these strings stretched tight and moving the ends around, they could draw parts of two perfect circles. These parts—circles we call arcs—will cross each other at two points. When the builder draws a straight line between these two points, he will find it bisects the original line, that is it crosses it at a right-angle, cutting it into two equal parts.





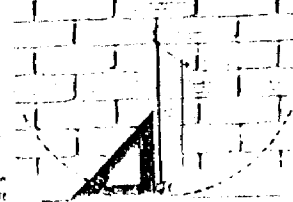
The builders of ancient Egypt checked that their walls were built at right angles to the ground by means of a plumb line.

The builder must be able to mark out right angles on the flat ground to get his foundations square. To test whether his walls are dead upright, he also needs to make right angles in the air. For this purpose, the Egyptian builders used the plumb-line, a device we still use today. If the plumb line is suspended from the top of a wall so that the weight is free to swing, it traces an arc of a circle, and comes to rest at right angles to the ground. If level with it, the wall is vertical.

Of all ways of drawing a right angle, the simplest is to use a set square. The Egyptians did so. But first they had to make one, and to do this they had first to make a right-angled triangle.

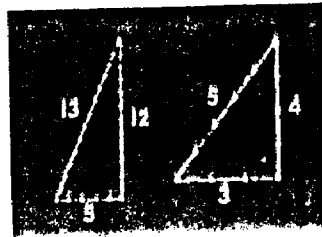
Who first made this discovery we may never know. Possibly it was the professional rope knotters whose job it was to tie equally-spaced knots in the long ropes used for measuring. Somehow they found that pegging out certain lengths of rope in the form of a triangle produces a right-angle opposite the longest side. Taking a length

When plumb line stops swinging, it shows the ground at right angles.



as the space between two knots, one combination that gives this result is a length of 4 lengths, 4 lengths and 5 lengths. Another is 3, 4 and 5. By cutting pieces of wood of such lengths and by joining them end to end, they could make a set square.

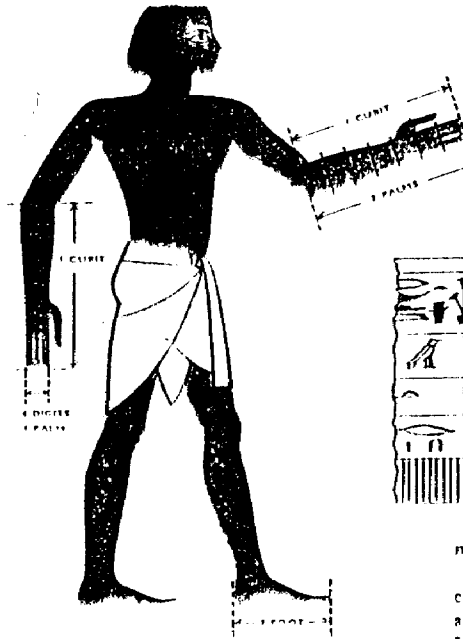
Crude ways of measuring, good enough for their forefathers, were not good enough for these builders of great temples and pyramids. The farmer who set out to build a stone or wooden hut with his own hands could say: My hut will



A triangle with sides 3, 4, 5 lengths has a right angle.



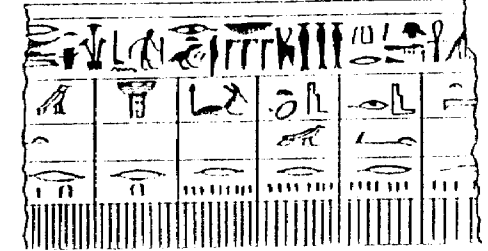
Two men are laying out a square on the ground by using a rope.



Early measures were based on the proportions of a man's body.

Part of an Egyptian measure, with marks for fractions

Egyptian fractions were always one part of something. The sign for 'one part of' was $\frac{1}{n}$. Fractions shown below are $\frac{1}{10}$ ($\frac{1}{10}$), $\frac{1}{9}$ ($\frac{1}{9}$), $\frac{1}{8}$ ($\frac{1}{8}$) and $\frac{1}{7}$ ($\frac{1}{7}$).



Marie Perle, Texas

not by any means difficult to talk of three palms.

These early measures seem strange at first, but equally strange ones are still in use. A Briton or an American still measures his own height in feet. He still says 'seven inches' to avoid using the fraction 'seven-twelfths of a foot'.

At harvest time each year the priests of Egypt levied payment for their services by collecting taxes from the farmers who paid in goods. To fix the payment due, there had to be standard jars for measuring out grain, wine or oil, and standard weights for weighing other produce.

he six paces long and four paces wide, the roof will be a hand span higher than the crown of my head. The temple architect could not give building instructions in paces and spans. Every workman under him might have a different pace and span.

For large-scale building there had thus to be measures that were always the same, no matter who did the measuring. In the beginning they were commonly based on the proportions of one man's body, possibly a king's. These standard measures were fixed by rulers of wood or metal.

In Egypt the main standard of length was the cubit, often mentioned in the Bible. It was the length of a man's forearm from the elbow to the tip of the outstretched middle finger. There were also smaller measures: the palm, one seventh of a cubit, and the digit, one quarter of a palm.

Such smaller units were very important to the Egyptians because they found fractions hard to handle. We now think easily of fractions such as three fifths, or nine tenths, but a fraction to an Egyptian was always one part of something. It was so hard to think of three-sevenths of a cubit but



A jar was used for weighing grain for measuring.

Marie Perle, Texas



Before gathering taxes the priests measured the area of each field. Odd-shaped fields were first marked off into triangles.

It seems that the amount of tax depended on the size of the farm; the bigger the farm, the bigger the tax. To levy taxes, the priests therefore needed some way of measuring area.

Perhaps their first clue to area-measurement came when paving the floor of a temple with square tiles. A strip of floor six tiles long and six wide needs thirty-six tiles (6×6) to cover it. Another



Base 3, height 3. Area 9.

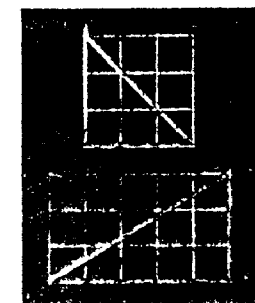


A square folds into two triangles. Each is half the area of the square.



Base 6, height 3. Area 18.

A rectangle cuts into two triangles. Each is half the area of the rectangle.



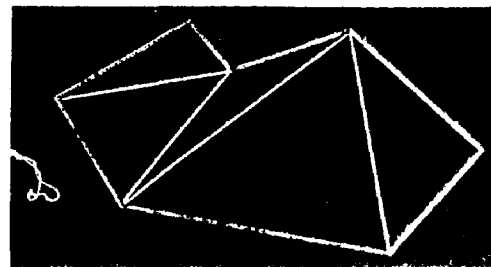
The area of any right-angled triangle is half the area of the square on which it is based.



area of a triangle he could thus measure any field, providing its sides were all straight.

Happily it is only a short step to learn how to find the area of a triangle once you know how to find the area of a square or an oblong. A square piece of linen will fold into two equal triangles, each half the size of the square. An oblong piece will cut into two equal triangles, each half the size of the oblong. Possibly such simple clues gave the priests a guide to the rule they needed. They saw that we find the area of a triangle by multiplying its base (or length) by its height (or width) and dividing the answer by two.

The job of measuring the fields kept the priests busier than we might think. The farmland of Egypt lies in a narrow strip near the great River Nile. On either side of this fertile strip, all is desert. At midsummer each year the river overflows its banks, watering the nearby land and leaving behind a thin layer of rich, muddy soil when the floods go down again. This yearly flooding helped the early farmers of Egypt to



By measuring every triangular strip we can find the total area.

grow fine crops, but it also washed away the boundary marks between their fields. So the priests had to measure each plot of land again and again, year in and year out. They were not merely calendar-makers and architects. They were also the world's first professional surveyors.

Ever since the days of the Egyptians, the main working method used by surveyors of all ages has been what they call triangulation. When we think about how much the early priest-surveyors must have learned about the shapes and areas of triangles, we begin to see how much the mathematicians of later times gained from their practical knowledge. To it, we owe the very word *geometry*, not to up



Food grows only where the Nile floods. Beyond, all is desert.

from two Greek words, one meaning earth or land and the other measurement.

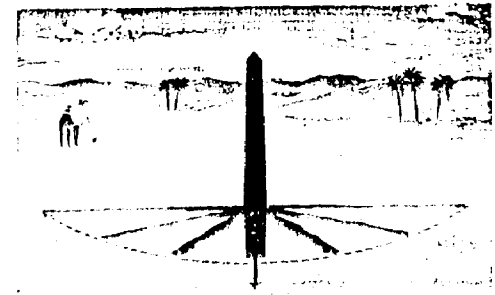
Of course, the surveyor meets problems that he cannot solve by the simple rule for finding the area of the triangle. He cannot mark out a circle in strips which are exactly triangular.

The early Egyptians almost certainly drew circles by pulling a tightly stretched cord around a fixed peg. They knew they must use a long cord to draw a large circle and a short cord to draw a small one. They knew, in fact, that the area of a circle depends on the distance from its middle-point to its edge, or on what we now call its radius.

About 3,500 years ago, when the great pyramids were already very old, an Egyptian scribe named Ahmes, the Moonborn, put a rule about this in writing. The area of a circle is very nearly three and one-seventh times as great as the area of a square drawn on its radius. That is, if the radius is 3 inches, the area of the circle is roughly 31×9 square inches. How the priests made this discovery we may never know. In the British Museum in London hangs the carefully framed papyrus manuscript written by Ahmes himself. Unfortunately it gives us no explanation.

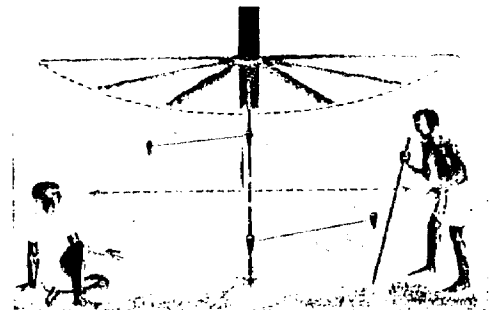
Symbol for entrance

Finding North and South



North of the Temple of Cancer, the sun's noon shadow points always due north

Finding East and West

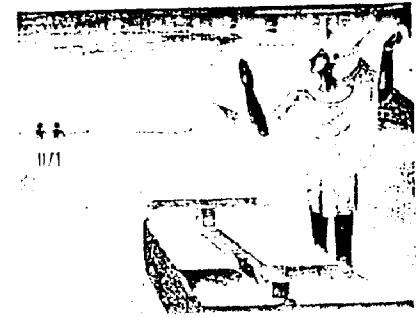
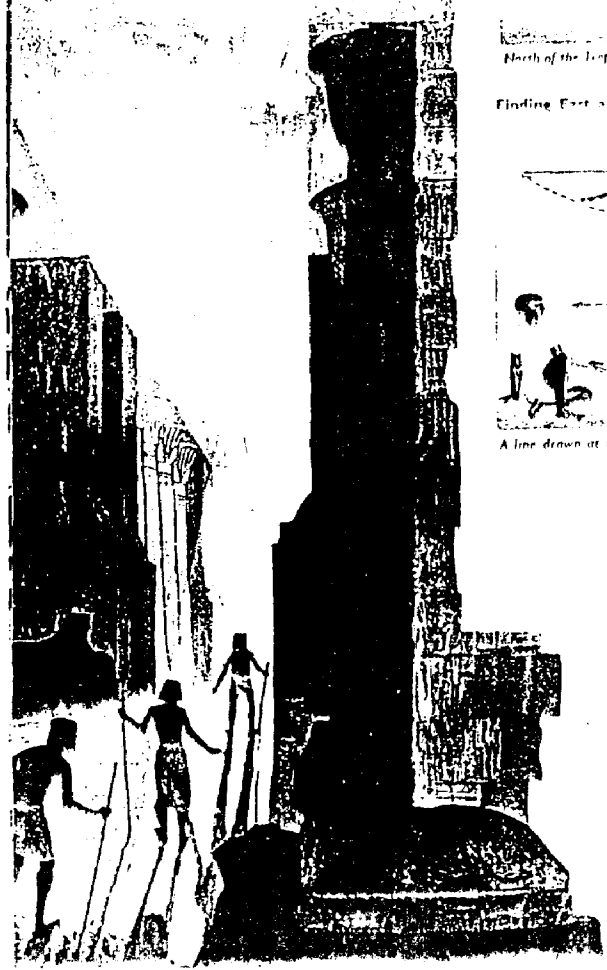


A line drawn at right angles to the noon shadow points due east and west

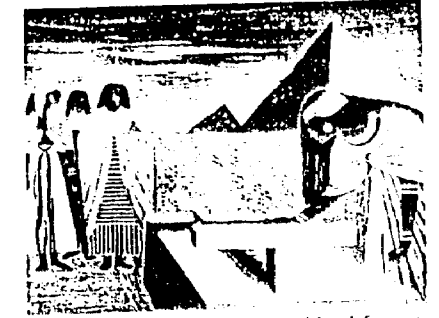
For God of the Sun, holds the scepters of east and west.



The temple at Karnak was built in such a way that at an equinoctial day a sun beam falling through the columns would trace the figure of the god.



At dawn this Egyptian sundial was set with its crossbar facing towards the east. The longest shadow marked the sixth hour before noon. At mid-day, when the shadow was shortest, the dial was turned round. Slowly the shadow lengthened and marked the afternoon hours.



Scattered in museums around the world there are other early manuscripts which give us a glimpse into the mathematics of Egypt, but most of our knowledge comes from examining the ancient buildings which still stand near the Nile.

We can tell how accurately the priestly architects could fix direction from the fact that the four faces of certain pyramids look precisely toward north, south, east and west. The architects probably found north and south from the noon shadow of some tall column. By drawing a line at right angles to such a shadow, they could place east and west as well.

There is also another way of finding east which the Egyptians must have understood. Day by day, the sun's rising position gradually changes. In winter it rises to the south of east, in summer to the north of east. If you can halve the angle between its midwinter and midsummer rising positions you will know what is due east.

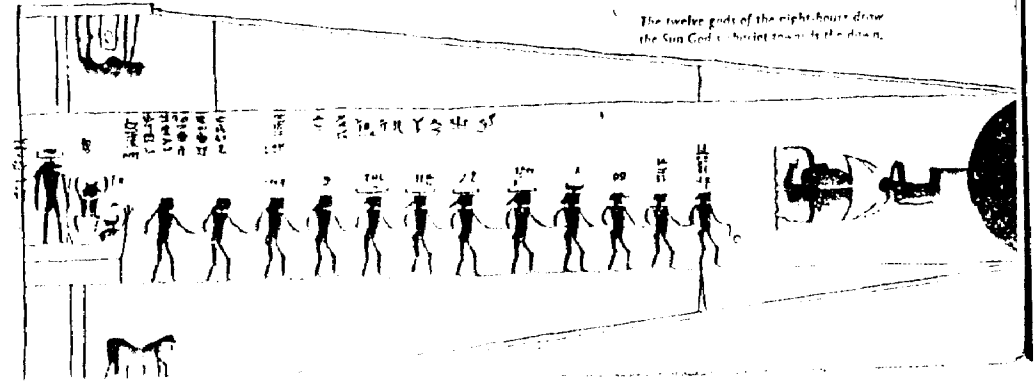
By counting the days between two occasions when the sun reached its most northerly rising position, the Egyptians could measure the length of

the year. At Karnak they built a temple with a line of columns pointing to where the sun rose on midsummer's day. Only once in 365 days did the rising sun shine straight along that line.

In finding direction and measuring time, the Egyptian had only the same clues as the hunters and food-gatherers of a bygone age: the rising and setting positions of sun, moon and stars, the shadow of the sun by day and the rotation of star-clusters around the Pole Star at night. Years of careful recording, however, enabled the Egyptian to make far better use of these clues. The early hunter looking at the long shadow cast by a tree could say at best: It is still early morning. The Egyptian, with a sun clock which measured the length of a shadow falling on a marked strip of wood, could look at the shadow and say: The second hour of morning is at hand.

Here we have real science: but many of the priestly drawings of ancient Egypt show the gods busy controlling the points of the compass or the hours of day and night. Along with real science they trailed a heavy load of superstition.

The twelve gods of the night-hours draw the Sun God's chariot round to the dawn.



"Taxes & Triangles" Assignment (Work in groups of 3 or 4).

- 1) The Egyptians, in building their pyramids, needed to construct a perfect rectangular base. With a piece of string, some thumb tacks and an A4 pad, can you use the Egyptian method to construct a perfect rectangle?
- 2) The tax-gatherers of ancient Egypt needed a way to fund the area of a farmer's land in order to collect the correct taxes for the field. We know that the area of a square is length x breadth. Yet, what happened when a part of a farmer's property was a *triangle*? Describe how the tax-gatherer derived the area formula for a triangle using a square to begin with.
- 3) How could priestly architects be so accurate when determining the north, south, east and west directions of a pyramid's faces?
- 4) Describe in your own words an astronomical method (astronomy implies, "with the aid of sun, moon and stars") for determining due east.

Hence, explain how the Egyptians determined the length of a year and what the agricultural significance of this actually was. Thus, how important was Science to the Egyptian? (You may have to do some outside reading here.)

Special Assignment:

In all these geometric constructions and calculations, the Science of Mathematics is being used to assist the Egyptians towards preserving their culture.

In groups of 4, visit the library in the afternoon and read up about ways in which Mathematics preserves your own culture. Describe examples and even build models to illustrate the point that Science is intertwined in the tapestry of our culture.

Tailpiece:

Should you have a special interest in Egyptology then research further and focus particularly upon the circumstances surrounding the interpretation of hieroglyphics revealed via the

ROSETTA stone. Note that the person responsible for describing the characters was Jean Frangois Champollion in 1828.

UNIT 3

THE SCIENTIFIC METHOD : A STUDY OF THE PROCESSES OF SCIENCE

General Comment

Today, we will learn about the processes of Science by doing an experiment.

Outcome

The learner must be able to *use* process skills to determine which factor(s) are responsible for the time of swing of a pendulum.

Assessment Criteria. (This is what you will be judged upon.)

Learners are to conduct a focused investigation in which they can:

1. identify contributing factors from the literature.
 2. formulate hypotheses (ie educated guesses of factors which may be involved)
 3. make predictions
 4. implement plans of action
 5. collect and record evidence
 6. analyse evidence
 7. interpret conclusions
 8. communicate conclusions.
-

The Experimental Approach

Most investigations begin with a research question. The one I have selected for you is:

WHAT FACTOR(S) WILL INFLUENCE THE TIME OF SWING OF A PENDULUM?
--

In groups of three, brainstorm what you think is the possible sequence of procedures and list them below:

PROCEDURE	COMMENT IF NECESSARY

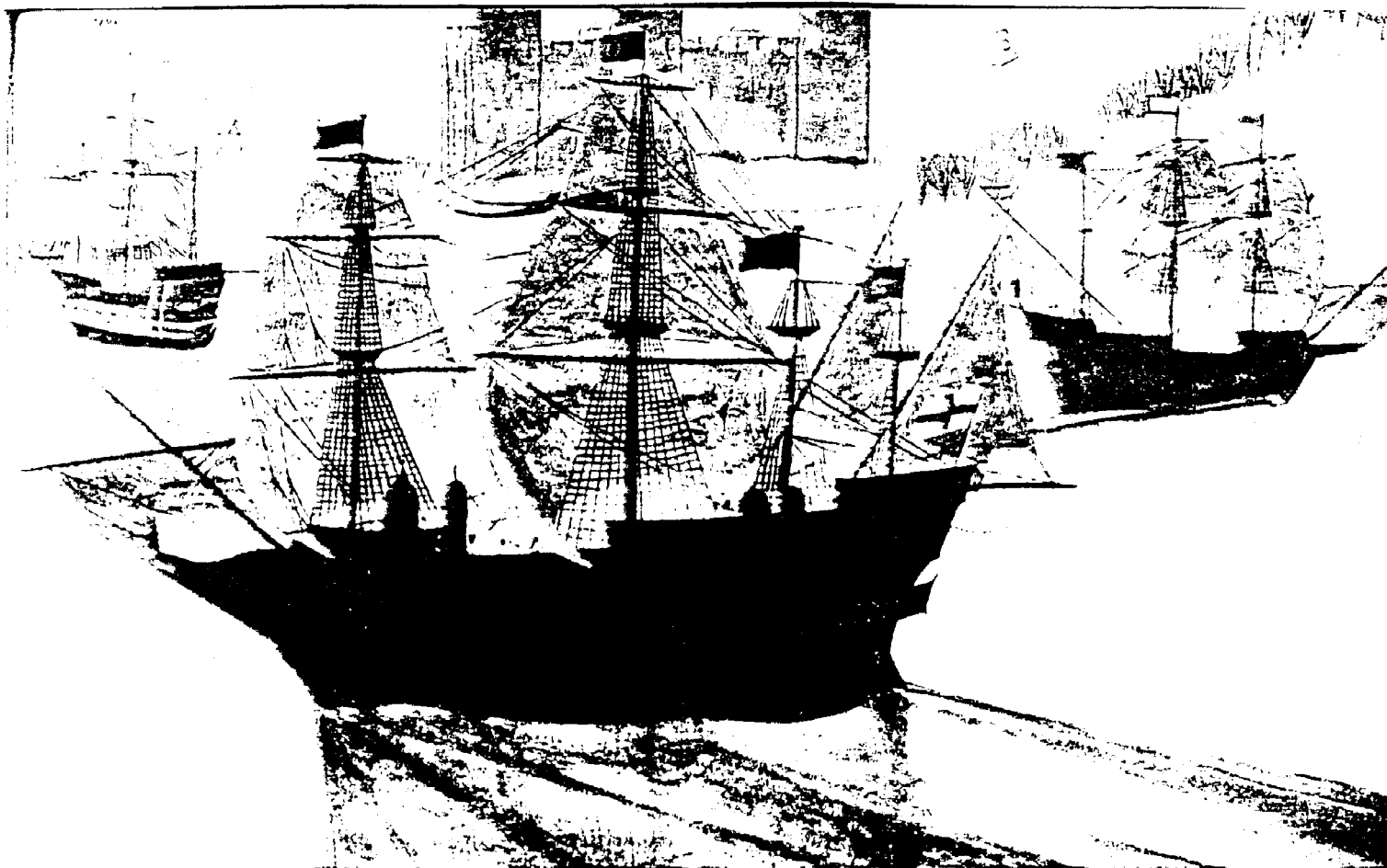
Sequence of Procedures

Step 1 : Reading possible sources of information

Very often what is required of you in a practical investigation is neatly recorded in reference books, for example, encyclopaedias, Science textbooks, Science magazines, books of general scientific interest etc ...

To assist you for the moment, I have selected an appropriate reading which provides valuable clues as to what these “factors” might be. It is your task to read through the article and extract possible factors responsible for the time of swing of a pendulum. Note that in future you may be called upon to locate your own reference articles. For the moment, however, read the article: Graphs & Gravity by Lancelot Hogben (1955).

Reference: Hogben, L. (1955) MAN MUST MEASURE: THE WONDERFUL WORLD OF MATHEMATICS. London: Rathbone Books.

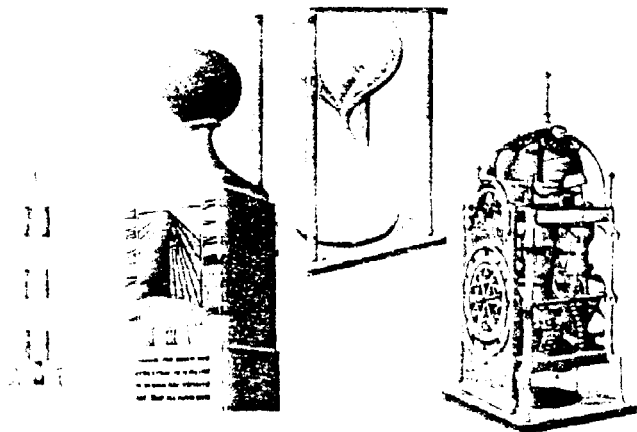


Graphs and Gravity



COLUMBUS and Drake, Vespucci and Mageilan, and all the other great sea-captains whose ships opened up new east-west sea-lanes across the Atlantic, were faced with one problem that sometimes proved a matter of life or death – the problem of finding longitude. Long after the days of these pioneers, one captain, when almost within reach of the island for which he was bound, imagined that he had sailed too far west and passed his objective. He then sailed east for three hundred miles before realising his mistake and turning westward once more. During the wasted voyage of six hundred miles many of his crew died of hunger or scurvy.

Before there were new and easier methods of finding longitude, the explorer-mariner had no means of locating the positions of ports accurately on his map. To fix your longitude, you need to know the time where you are and to compare it with the time at some other fixed point. By comparing the times when eclipses of the moon were visible at different places, the geographer Ptolemy of Alexandria was able to fix, roughly, the longitude of some half-dozen places. Moslem astronomers and geographers knew the longitude of perhaps a score of towns. This was a great gain; but the captain of an ocean-going ship needs a way of fixing the longitude of any place at any time, and for this he must have dependable and accurate time-keeping instruments.



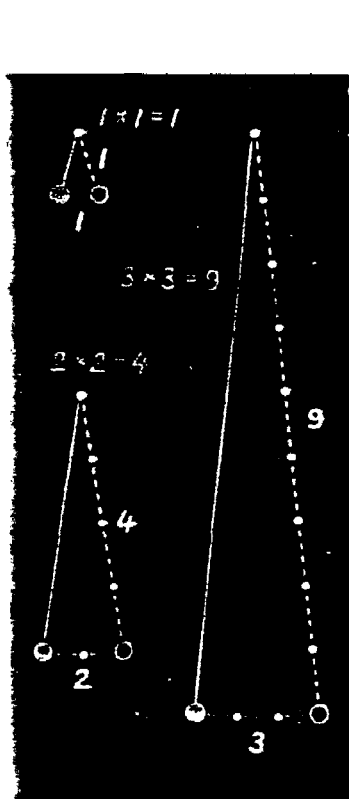
Early time-keepers, the Middle Ages added only crude clocks.

In the Age of Discovery, with ships crossing the world, men therefore needed to measure minutes and seconds accurately. For this purpose crude weight-driven clocks such as churches and monasteries had installed during the four previous centuries were of no more use than the candle-clocks, the sun-dials and the hour-glasses on which the ancient world depended.

The first clue to accurate measurement of small intervals of time was discovered in 1583, when Galileo, a young Italian medical student, watched a lamp swinging to and fro in Pisa Cathedral. Timing its motion by the beat of his



A swinging altar-lamp gave a clue to the law of the pendulum.



Red lines show length, blue show time. Length determines the time of swing.

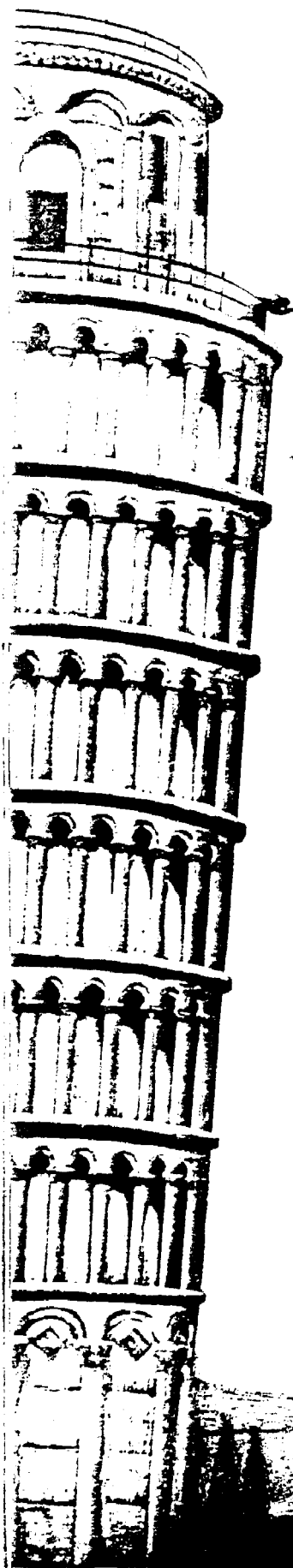


Early pendulum clock.

pulse, Galileo found that all swings, whether wide or narrow, took the same time.

Later on, when Galileo gave up the study of medicine to take up mathematics and physics, he used a home-made water-clock to check the accuracy of this observation. While a pendulum was swinging, he allowed water to flow from a hole at the bottom of a large vessel and fall into a small one below it. If the weight of water that escaped during two separate swings was the same, he knew that both had taken an equal time.

His experiments showed that the time of swing depends only on the length of the pendulum. To double the time of swing you must make your pendulum four times as long; to treble the time of swing you must make your pendulum nine times as long. The length of the pendulum varies in the same ratio as the square of the time of swing. We now know that this rule, while correct for narrow swings, is not quite accurate when the pendulum swings through a very wide arc. In 1657 the Dutch scientist, Huygens, made use of Galileo's discovery to produce accurate pendulum-regulated clocks.



• One second

• Two seconds

Dropping weights from a height, Galileo proved that heavy things and light ones fall at the same speed. The farther any weight falls the more speed it gathers.

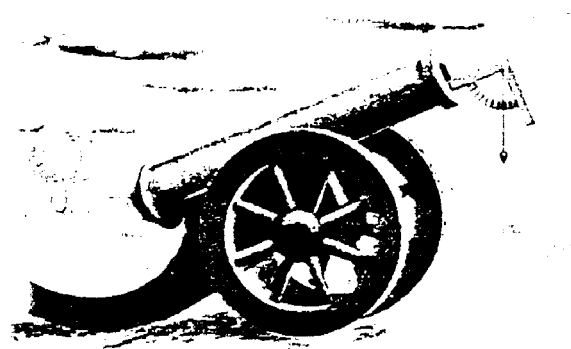
Three seconds



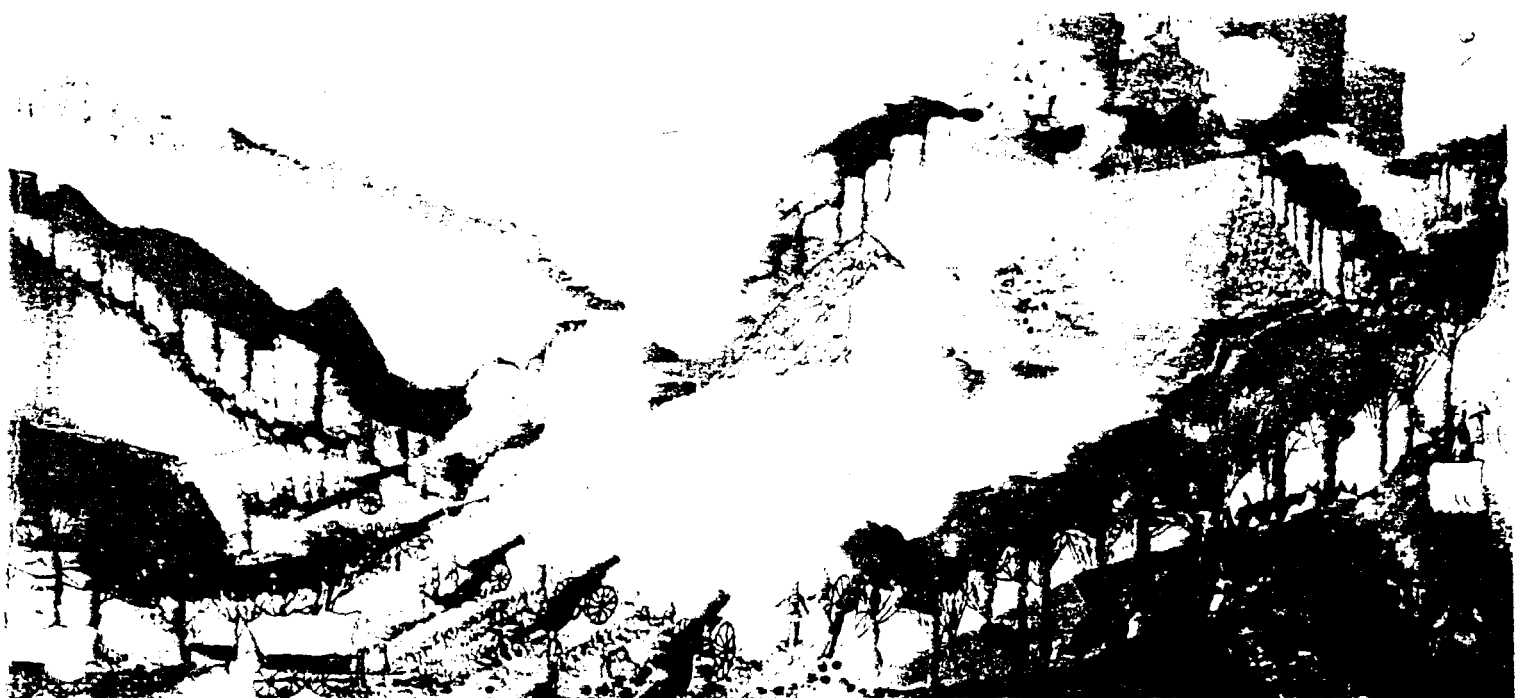
As a ball rolled down a slope, Galileo measured its acceleration with a water-device.

Before Galileo's time, people believed that the heavier an object was, the faster it would fall. Galileo's pendulum experiments, however, disproved this. For he found that the weight of the bob at the bottom of the pendulum has no effect on the time of swing. To settle the matter beyond dispute, he dropped two different weights simultaneously from the Leaning Tower of Pisa. Both the heavy one and the light one hit the ground at the same instant.

Galileo recognised that both weights increased their speed, or accelerated, as they fell. In his day there were no stop-watches for split-second timing. So he found it impossible to measure the acceleration directly. He realised, however, that gravity acts on a ball rolling down a slope just as it acts on a falling weight; but the slope itself then slows down the speed of the ball. He therefore



Sixteenth-century effort to apply mathematics to range-finding.



The cannon completely revolutionised warfare. Once-magnificent forts, high up on hilltops, made easy targets for the new weapon.

rolled a ball down a sloping board and timed it as he had timed the swing of the pendulum.

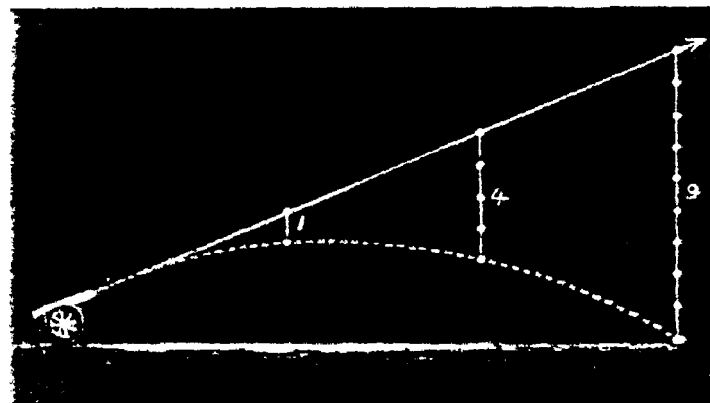
He found that in two seconds the ball rolls four times as far as in one second; in three seconds it rolls nine times as far as in one second. The distance it rolls varies in the same ratio as the square of the time it rolls.

This discovery makes it possible to work out the kind of path a cannon-ball follows as it hurtles through the air. At the instant it leaves the mouth of the cannon, it would move in a straight line pointing in the same direction as the gun-barrel, if there were no force of gravity to pull it downwards at a uniformly increasing rate. But because of the pull of gravity, it travels along the kind of curve which we call a parabola.

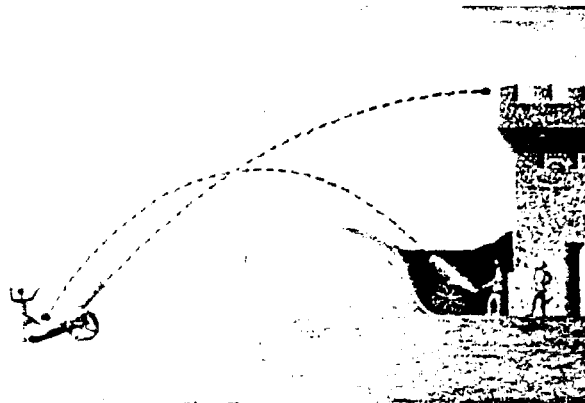
Before the time of Galileo, mathematicians had tried, without much success, to advise the artillery-

man about how to decide the correct elevation for the cannon when he knew the distance of the target. When it was possible to understand how gravity affects the flight of the cannon-ball, it was also possible to work out tables of elevation, based on the distance of the target. This distance, together with the speed of the ball, decides how long the ball will be in flight and hence how long the force of gravity will be acting on it.

In the seventeenth century, military engineers trained in mathematics designed new fortifications to withstand attack by cannon. Low-built forts protected by earthworks replaced hillside fortresses which enabled the defenders of earlier times to fire down on their attackers. The new ones confronted the attackers with a more difficult target, while the defenders, with cannons placed low, could answer their fire as effectively as from a height.



Shot falling faster and faster from course, travels in a curve.



Knowledge of cannon-ball's path changed system of fortification.

Step 2 : Making hypotheses (ie guesses as to what factors may be involved)

Now although you may have found factors recorded by other researchers in the literature, it very often differs slightly from your investigative demands.

Thus, you are forced to take what you have read and *guess* what may be responsible for the time of swing. Try and formulate these so-called educated guesses or “hypotheses”.

RECORD THE POSSIBLE VARIABLES BELOW:

- (1)
- (2)
- (3)

What do you
understand by a
variable?

STEP 3 : Making predictions

You must now think practically and predict (say in advance) what will happen when you try various experimental procedures. For example, what do you think will happen when you vary the mass of the bobs?

IN THE SPACE BELOW, RECORD YOUR PREDICTIONS IN WORDS

Step 4 : Decide on an experimental design and implement

Design an experiment that would be suitable to determine the factors influencing the time of swing of a pendulum. Do it in the following way:

LIST OF APPARATUS TO BE USED

DIAGRAM OF ARRANGEMENT OF APPARATUS

SUMMARY OF KEY POINTS TO BE FOLLOWED WHEN DOING THE
EXPERIMENT

Once you have done this, select another independent variable other than length of the pendulum. This variable may now be tested. Tabulate your results in the table below.

	INDEPENDENT VARIABLE II	DEPENDENT VARIABLE I	VARIABLES REMAINING CONSTANT THROUGHOUT
TRIAL I		1. 2. 3.	
TRIAL II		1. 2. 3.	
TRIAL III		1. 2. 3.	

	INDEPENDENT VARIABLE III	DEPENDENT VARIABLE I	VARIABLES REMAINING CONSTANT THROUGHOUT
TRIAL I		1. 2. 3.	
TRIAL II		1. 2. 3.	
TRIAL III		1. 2. 3.	

NOTE: Remember that you are only allowed to change one variable at a time while keeping the other variables constant. (This is a vital part of the experiment. Should you not understand what is being said, discuss the issue with your mates and try and figure it out together.)

Step 5: Collection and recording of evidence

To concisely record measurements, we make use of tables (ie we tabulate the results).

Example:

	INDEPENDENT VARIABLE I Lenth of pendulum in metres	DEPENDENT VARIABLE I Time of swing in seconds	VARIABLES REMAINING CONSTANT THROUGHOUT
TRIAL I		1. 2. 3.	
TRIAL II		1. 2. 3.	
TRIAL III		1. 2. 3.	

What do you understand by dependent and independent variables?

INDEPENDENT VARIABLE: is one in which, for each set of trial runs, the length of the pendulum will not change.

DEPENDENT VARIABLE: is one in which, for each set of trial runs, the time of swing will depend on some other factor, namely, the length of the pendulum.

QUESTION

You will notice that in each trial you have to repeat the experiment at least *three* times. Why do you think this is necessary?

ANSWER:

Steps 6, 7 & 8 : Analyse Data, conclude and comment

When all of your experiments are complete then look at your data and decide with your friends what the data is revealing (ie saying to you). Look carefully for the trends (patterns) and then decide upon a conclusion which must answer the question:

WHAT FACTOR(S) WILL INFLUENCE THE TIME OF SWING OF A PENDULUM?

CONCLUSION

Additional comment: In a couple of sentences communicate the results of your experiments to another scientist explaining a few of the difficulties which you experienced.

ASSESSMENT SHEET

EXPERIMENT: FACTORS INFLUENCING THE TIME OF SWING OF A PENDULUM

LEARNER ASSESSED:

PERSON(S) RESPONSIBLE FOR ASSESSMENT:

.....

.....

USING THE SCALE:

0	1	2	3	4	5
Non-existent	Poor	Fair	Good	Very Good	Excellent

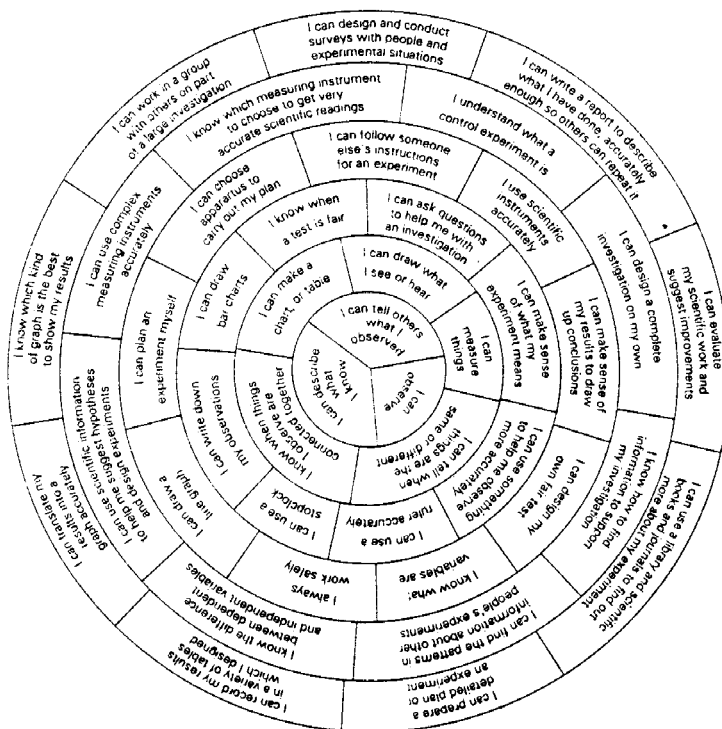
Assign a rating figure and decide on how you think you, your peer or your learner measured up to the various criteria listed in the table.

Criterion being assessed	Scale Rating	Criterion being assessed	Scale Rating
1. Learner's ability to identify possible factor influencing time of swing of pendulum after reading article		4. Learner's ability to implement plan of action.	
		5. Learner's ability to collect and record evidence.	
4. Learner's ability to formulate hypothesis.		6. Learner's ability to analyse data	
		7. Learner's ability to interpret conclusions.	
3. Learner's ability to make predictions.		8. Learner's ability to communicate conclusions.	

THE SKILL WHEEL :

SELF-ASSESSMENT

When you feel confident that you have in fact mastered a skill, colour it in on the Skill Wheel. Do not cheat since you are only fooling yourself and will be exposed later on when tested.



Module : Measurement – Equations – Ratio & Proportion

General Comment

This module is to be broken down into three units: Measurement – Equations – Ratio & Proportion.

Combining these skills, you will be expected to determine the height of rugby goal posts which is an example of how Mathematics may be used to better understand the environment in which we live.

Module outcome

The learner must be able to apply the skills of measurement, use of equations and the technique of ratio and proportion to determine the height of rugby goal posts.

Assessment criteria

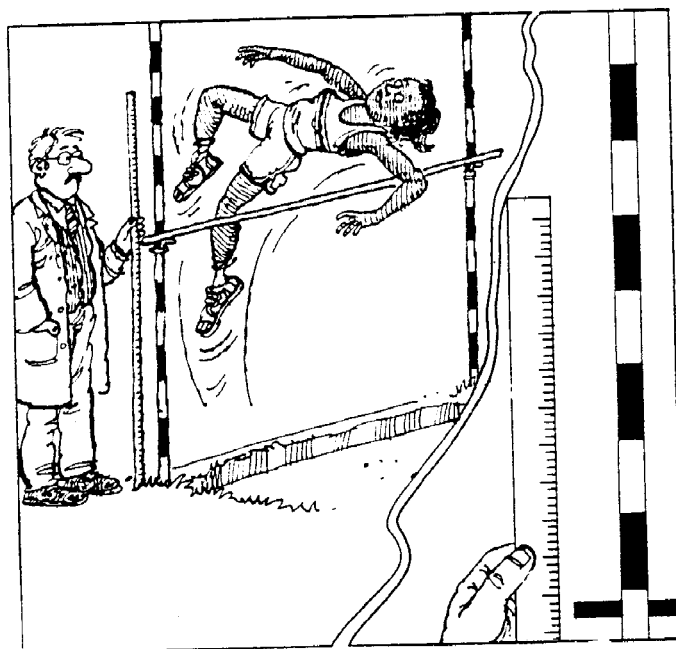
Learners are to show work in which:

- 1) problems are identified;
 - 2) the skills of equations, ratio and proportion and measurement are to be selected;
 - 3) the problem is to be evaluated and innovative ideas are to be generated;
 - 4) decisions are to be made;
 - 5) possible plans of action are to be communicated.
-

Unit: Measurement and units of length

General comment

A person who has a *skill* is very good at doing something. The athlete in the cartoon has a skill. She can jump higher than most people.



In Science, many skills are needed. Like a high jumper, you will have to practise these skills until you can cope with them. In this section you will learn the skills of measurement and use of appropriate units.

The judge in the cartoon has to measure accurately for medals may depend on it. In Science it is important to be able to read scales accurately. Solving a problem usually relies upon it.

Outcomes

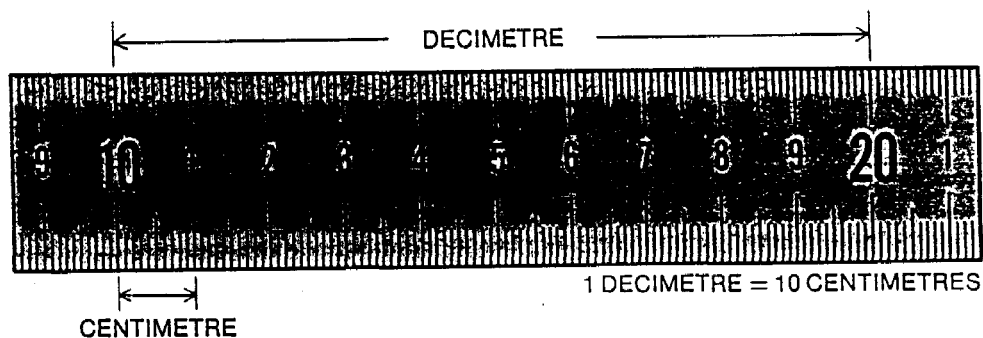
- 1) The learner must be able to read off certain prescribed lengths when presented with diagrams of ruler(???) and metre rules.
 - 2) The learner must be able to measure certain lengths using a ruler to the nearest millimetre.
-

Assignment

Try the following in your working groups. Use the metre ruler and rulers you have at your disposal.

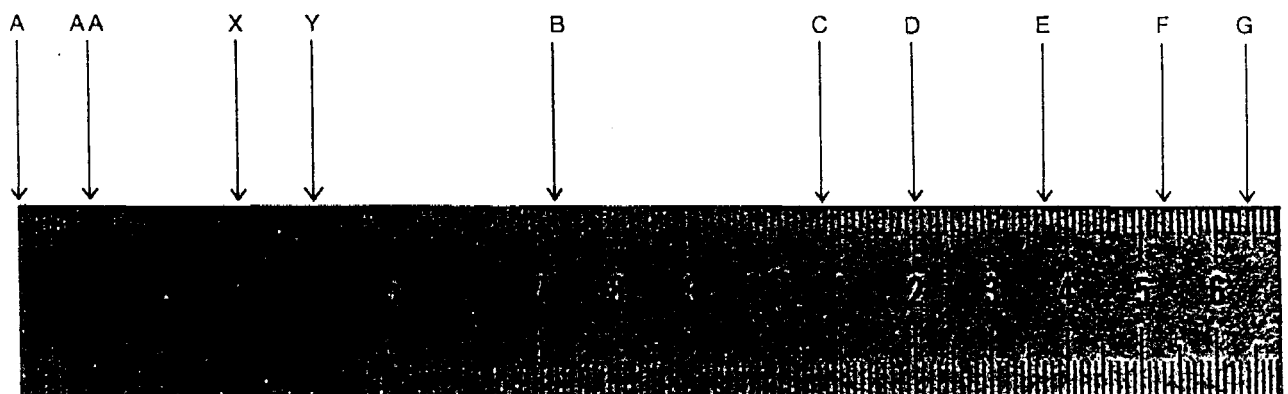
Questions

- 1) What part of a metre is one *centimetre*?
HINT: HOW MANY RUNS ARE THERE IN A CENTURY?
- 2) What part of a metre is one decimetre?
HINT: DECA IN LATIN MEANS TEN.
- 3) What part of a metre is one millimetre?
HINT: A MILLIPEDE IS SAID TO HAVE A THOUSAND LEGS.
- 4) Consider the figure



In figure A rank the units millimetre, centimetre and decimetre in order of size (ie largest to smallest).

- 5) Consider figure B



- (i) What is the distance from X to Y in centimetres?
- (ii) What is the distance from A to B in centimetres?
- (iii) What is the distance in centimetres between A and C?
- (iv) What is the distance from A to D?

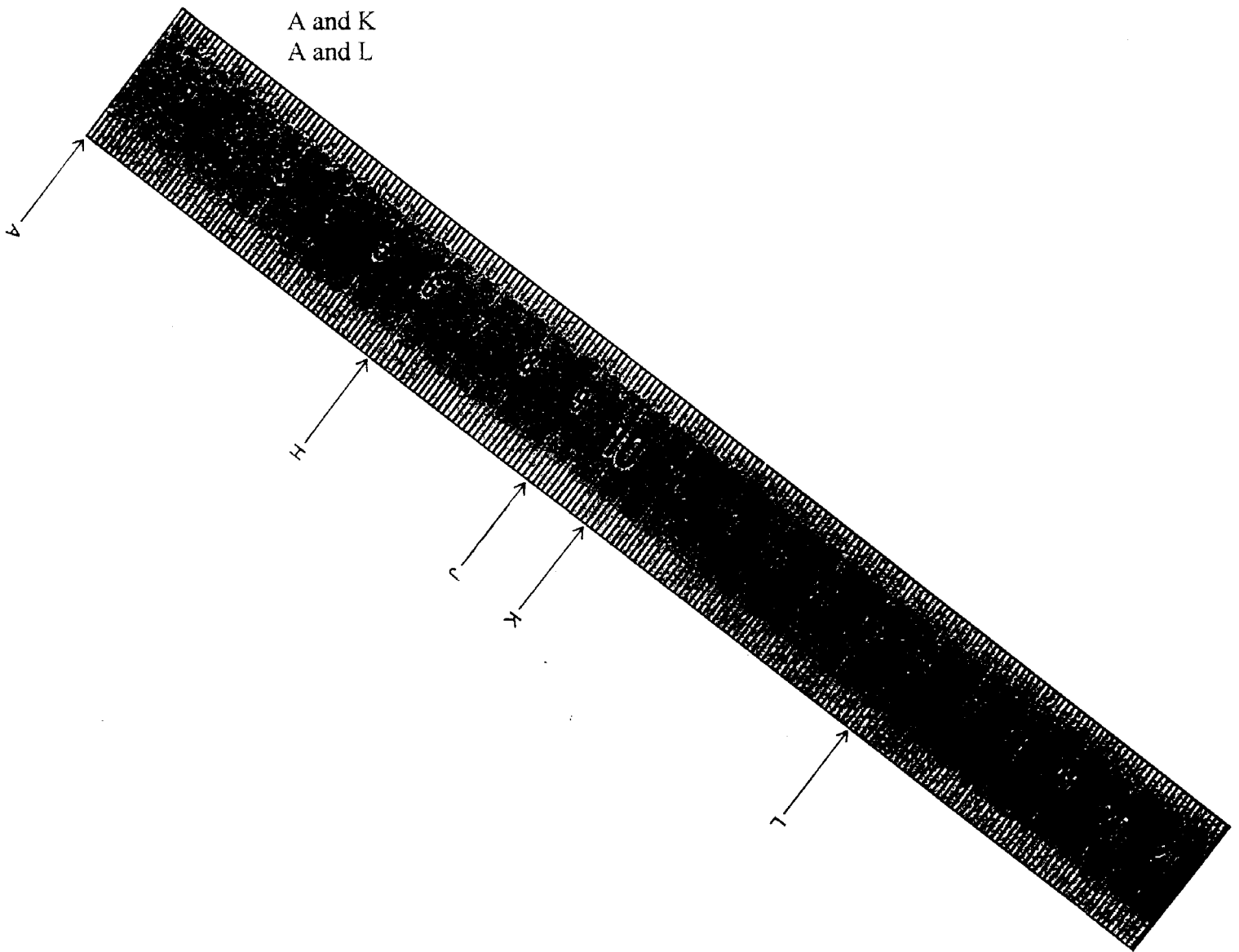
6) Find the distance between each of the following sets of points:

- (i) A and E
- (ii) A and F
- (iii) A and G.

7) Consider the figure below:

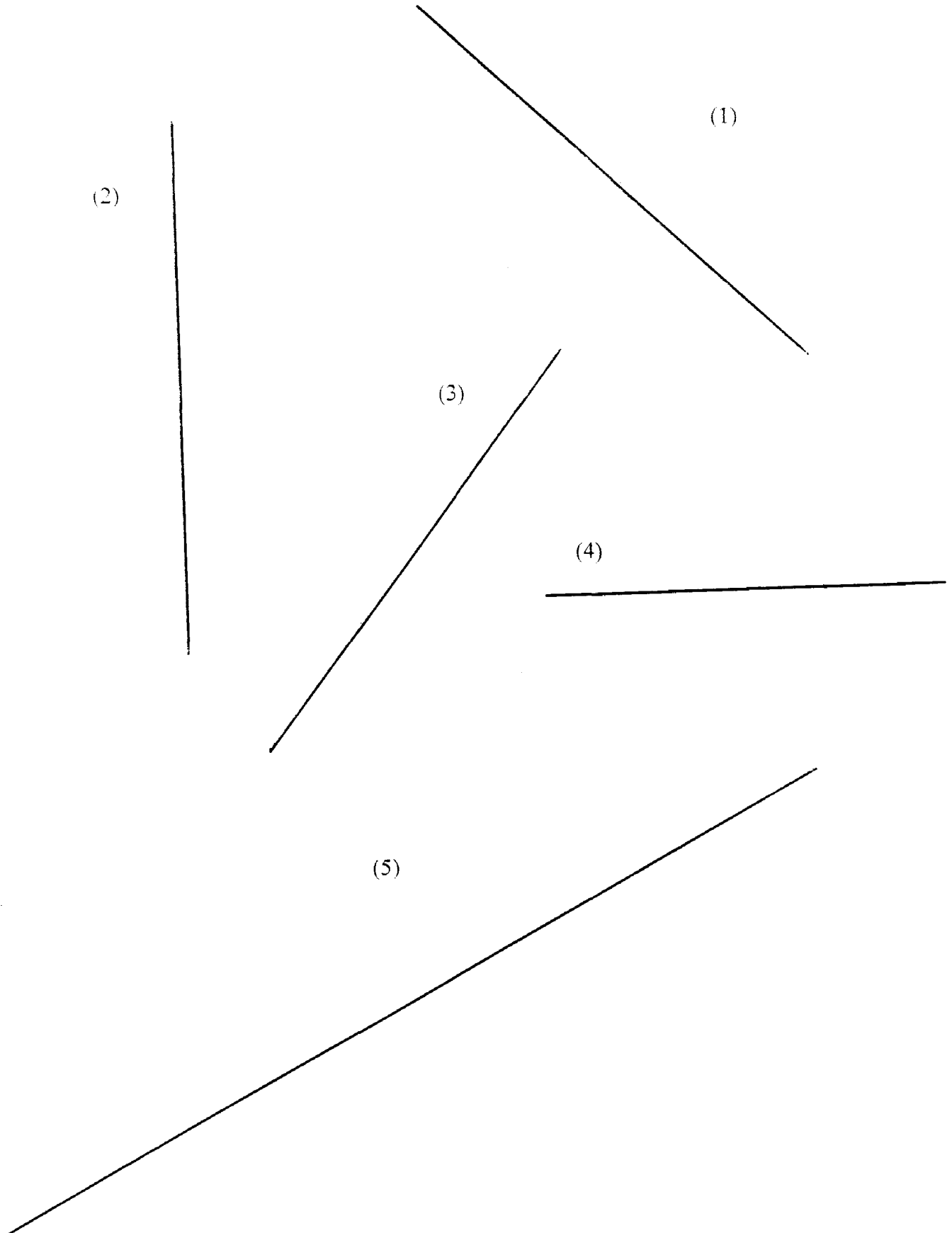
Find the distance in centimetres between each of the following sets of points:

- A and H
- A and J
- A and K
- A and L



Assignment: Measurement using Rulers

Measure each of the following lines accurately to the nearest millimetre.



UNIT ON ALGEBRAIC EQUATIONS

General Comment

This unit on algebraic equations will serve as a tool which you will surely need to study Science effectively, as physicists, for example, are always using formulae.

I have not included any outcome here, but have expressed objectives. Read these carefully as they will tell you exactly what you must be able to *do* at the end of the unit. Should you not be able to do the unit then speak up.

Objectives

- 1) After viewing a drawing of a balance, the learner must be able to solve pictorial equations by moving bags of unknowns and discs from the LHS to the RHS of the balance or vice versa.
- 2) The learner must be able to convert a pictorial equation to a proper algebraic expression of the equation and then solve algebraically.
- 3) The learner must be able to solve a simple equation by inspection, ie without manipulation.
- 4) The learner must be able to solve for unknown ' χ ' using the additive inverse.
- 5) The learner must be able to solve for unknown ' χ ' using the multiplicative inverse.
- 6) The learner must be able to change the subject of a formula.

NOTE: The attainment of these objectives can be assessed when learners provide written evidence of their activities.

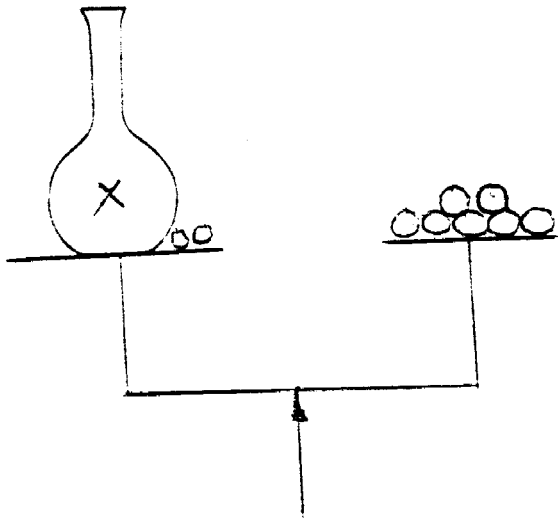
Reference used

Howat, R.D., Mullan, E.C.H., Nisbet, K. *et al* (1986). *Mathematics in action*. London: Blackie and Son Limited.

Pictorial Equations & Their Algebraic Equations

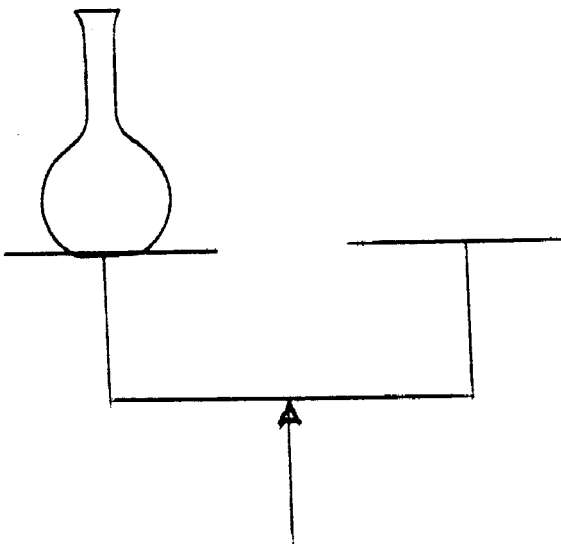
(1) Pictorial Equations

Algebraic Expression of Equations



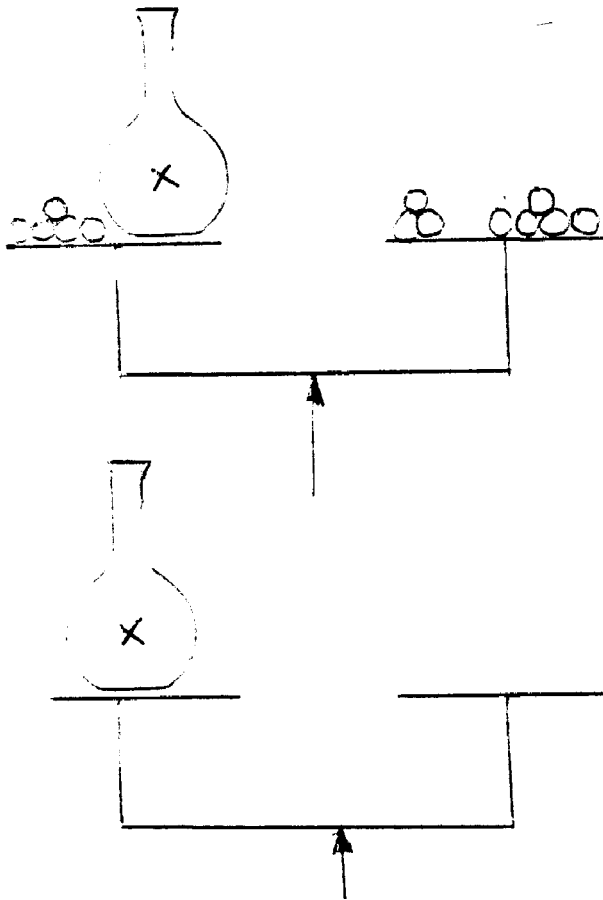
1) Pictorial Equations

Algebraic Expression of Equations



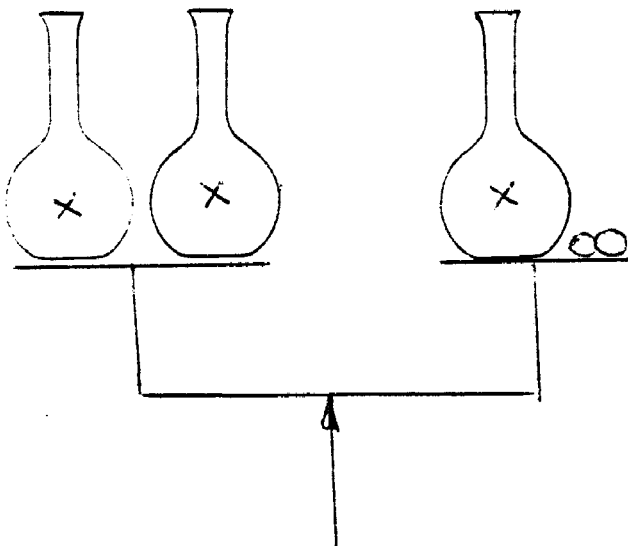
1) Pictorial Equations

Algebraic Expression of Equations

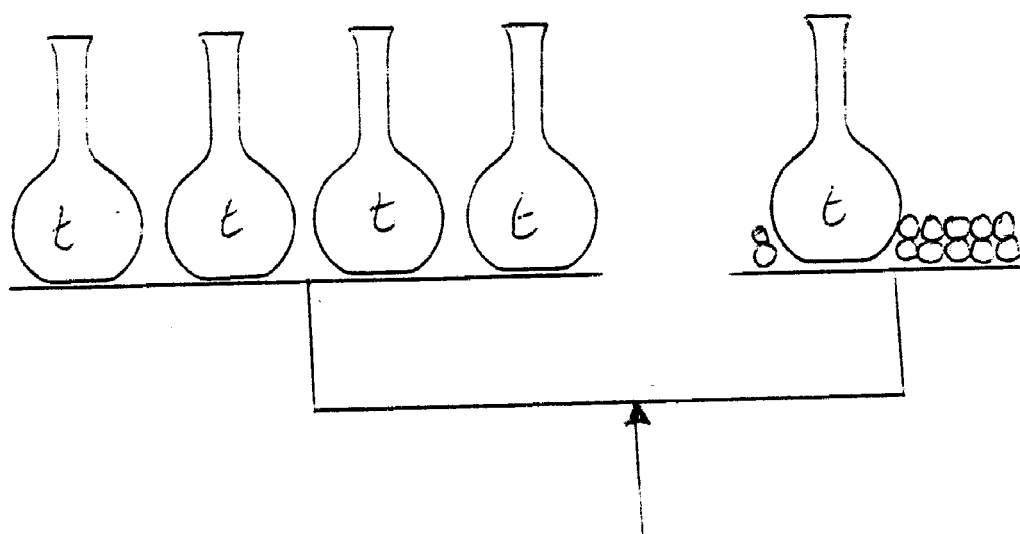
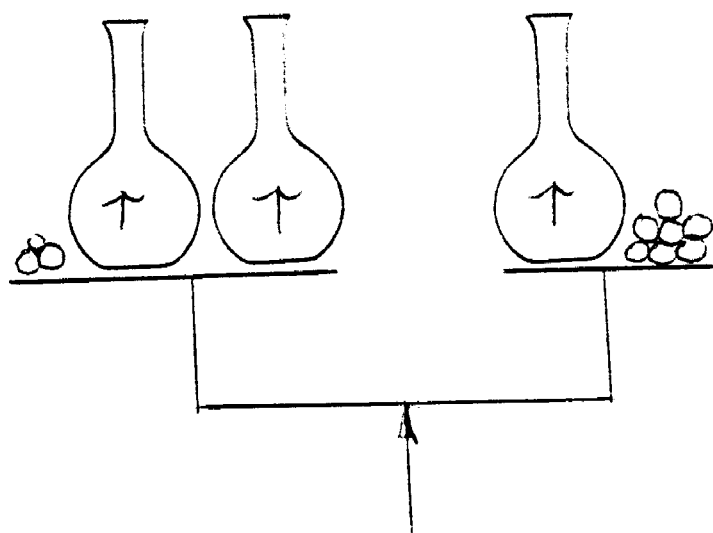
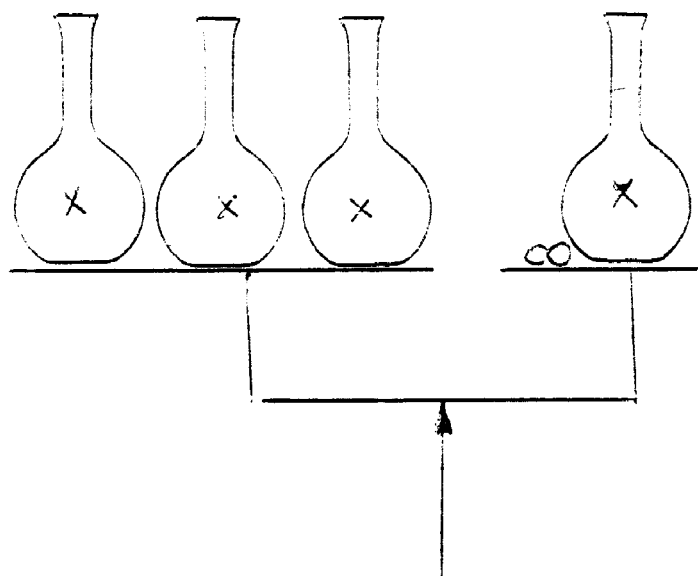


1) Pictorial Equations

Algebraic Expression of Equations



Algebraic Expression of Equations



SOLVING WITHOUT THE AID OF THE PICTURES

Do you remember your primary school work with equations. Do the following examples by writing down your answer.

1) $\square + 10 = 20$

2) $\triangle + 3 = 20 - 4$

3) $10 \times \square = 100$

4) $\frac{50}{\triangle} = 10$

5) $7 + 2\chi \quad \square = 12 + \square$

$7 = 2 \times \square = 12 + \square$; Boxes to be equal.

Now instead of the blocks $\square$ and triangles $\triangle$ to represent the unknowns, we use letters of the alphabet. Anyone may be used, but traditionally χ is the most popular.

Solving for χ by using the additive inverse

1) $\chi + 5 = 11$

Check

Try:

$$2) \quad x - 1 = 9$$

$$3) \quad 6 = 4 + x$$

Solving for x by using the multiplicative inverse

$$1) \quad 4x = 20$$

Check

$$2) \quad -6x + 6 = x - 22$$

Check

EXERCISE I: (ADDITIVE INVERSE)

Solve for x in each case supporting your answer with a check:

$$1) \quad x + 5 = 3$$

$$5) \quad 4x + 6 = 3x - 6$$

$$2) \quad 5x = 4x - 6$$

$$6) \quad 2x - 3 = x - 1$$

$$3) \quad x - 3 = -5$$

$$7) \quad -x - x - 2x + 5x = 3 \quad (-3) \quad (3)$$

$$4) \quad 3x = 4 = 2x - 5$$

$$8) \quad 6x - 7x = 6(7)$$

EXERCISE II: MULTIPLICATIVE INVERSE

Solve for x using the multiplicative inverse

$$1) \quad \frac{x}{2} = 7$$

$$5) \quad \frac{x}{2} + \frac{x}{5} = 7$$

$$2) \quad \frac{3x}{4} = 12$$

$$6) \quad 0,8x = 20$$

$$3) \quad \frac{3}{x} = 9$$

$$4) \quad 3x - 2 = 5x + 6$$

CHANGING THE SUBJECT OF THE FORMULA

Express y in terms of x :

$$a) \quad x = 3y$$

$$b) \quad x = y - 3$$

$$c) \quad x = 3 - y$$

$$d) \quad x = \frac{3}{y}$$

$$c) \quad x = 3 - y$$

$$d) \quad x = \frac{3}{y}$$

e) $2x = 3y - 24$

EXERCISE

In each case, make the letter between brackets the subject of the formula:

a) $A = \frac{1}{2} bh$ (h)

b) $C = 2\pi r$ (r)

c) $A = l \times b$ (b)

d) $A = \frac{1}{2} h (a + b)$ (h)

e) $R = \frac{V}{I}$ (I)

f) $E_p = mgh$ (h)

Enrichment Exercise

- 1) The formula for converting temperatures measured on °C to °F is

$$^{\circ}\text{C} = \frac{5}{9} (F - 32)$$

- a) Make F the subject of the formula
b) Convert a temperature of 5°C to F,
- 2) Manipulate each of the following formulae to make D the subject of the formula:

a) $L = 3D + K$

b) $\frac{D}{4} = 5L$

c) $A = \frac{\pi D^2}{4}$

c) $C = \pi D$

- 3) $V = \frac{1}{2} \pi r^2 h$ is the formula used to calculate the volume of a cone. Manipulate the formula to make:

- a) r the subject of the formula;
b) h the subject of the formula.

- 4) The acceleration of a motor car can be calculated by using the formula $a = \frac{v - u}{t}$. Manipulate the formula to make t (time) the subject of the formula.

- 5) Write down an algebraic equation for the breadth (B) of a rectangle if the length (L) is 5 times greater than the breadth.

- 6) The kinetic energy of an object is a measure of the work an object can do by virtue of its motion. The formula is: $EK = \frac{1}{2} mv^2$. Manipulate the formula to make:

- a) m (mass) the subject of the formula
b) v (velocity) the subject of the formula.

- 7) The formula for mechanical work done is $W = F \times d$. Manipulate the formula to make F (force) the subject.

- 8) The total resistance of resistors connected in parallel in a circuit is given by:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Make R_2 the subject of the formula.

- 9) The equation for the conservation of energy in a transformer is: $V_p I_p = V_s I_s$

Manipulate the formula to make:

- a) V_p (voltage in primary) the subject;
- b) I_s (current in secondary) the subject.

- 10) The following relationship exists for a transformer which does not lose energy in the form of heat or any other kind of energy:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

N_s is the number of times in the secondary coil. Manipulate the formula to make N_s the subject.

Write an account of no more than a page on the ways in which Science has influenced *your* culture.

You may use all resource books, (eg encyclopedias, journals, reference books), yourself or opinions of members of your community as references. Remember to mention the source in brackets after the name of the author, if applicable.

The test is a criterion-references test. This means that your performance will be based upon the following criteria:

- 1) Ability to have identified new ideas.
- 2) Ability to have consulted reference books.
- 3) Ability to have used correct grammar and spelling.

Your performance will be expressed as a percentage depending on how well you have met my criteria.

The test should be about 20 minutes and will be written without the aid of notes.

Unit : Ratio and Proportion

General Comment

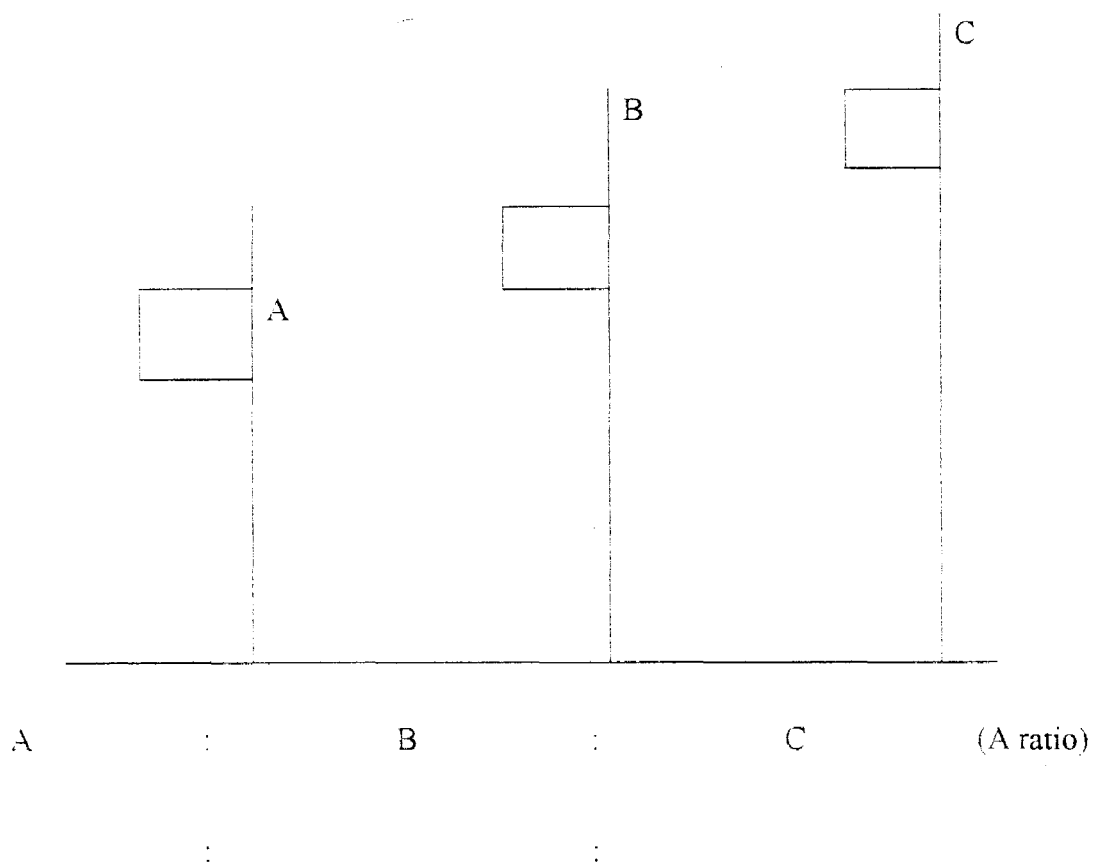
Ratio and Proportion is a crucial technique in Science for it helps the Scientist in many ways. For example, in the conversion of Physics units such as a velocity in $\frac{\text{Km}}{\text{h}}$ to $\frac{\text{m}}{\text{s}}$; it assists in

scaling of axes when drawing straight line graphs and in the drawing of bar graphs and pie charts as you will discover in the next module. Ratio and Proportion is truly a big ally.

Objectives

- 1) The learner must be able to express the lengths of lines in terms of a ratio in its simplest form.
- 2) The learner must be able to divide a certain quantity (eg mass, calories, length, time) into a ratio.
- 3) The learner must be able to determine by calculation the unknown quantities when using the method of direct proportion.

Assignment



Fill your answers in the blocks provided. Are the figures (ie the ratio) in their simplest form?

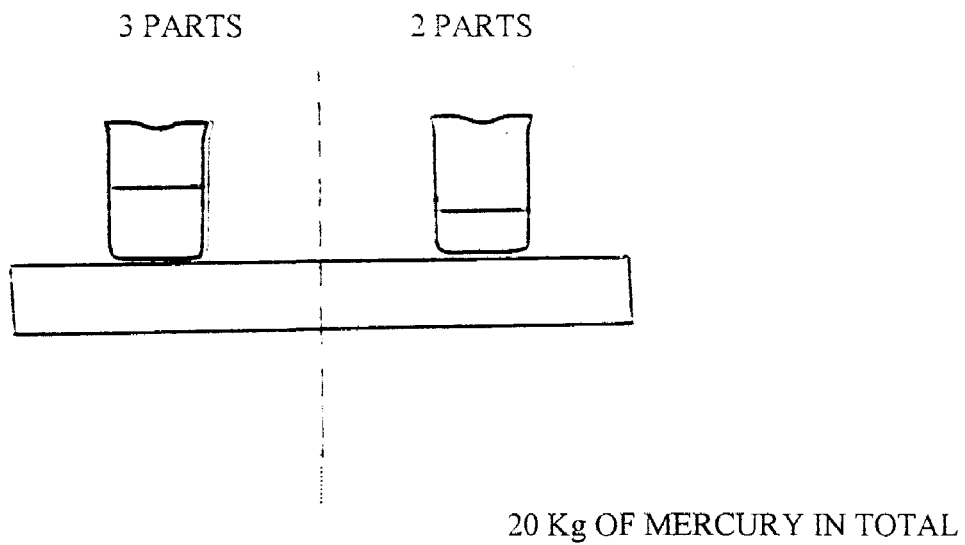
If not, then what can you do to reduce the ratio to its simplest form? Work in the space below.

Challenge: Try the following using your own methods.

Calculations involving ratios

The kilogram, as we will see later, is the unit of mass. For a particular experiment you may wish to divide 20kg of mercury in the ratio of 3:2. What will be the respective masses involved?

Diagram to assist you



Working

When you have figured out a way to divide the 20 kg of mercury, try out your method in the following examples:

- (i) Divide 16m in the ratio 3:1
- (ii) Divide 54s in the ratio 5:1
- (iii) Divide 60kg in the ratio 3:1

Do these examples on a separate sheet of paper.

Now, try a more challenging example:

1 kilogram of alloy is made up of copper, tin and nickel in the ratio 2:5:3. How many grams of each metal are there in the alloy?

Working

In a scientific experiment, Suzy wishes to measure the height of a poplar tree after 2 years of growth. She measures the trees as shown, but the poplar tree exceeds the length of her 10m long tape.

Suzy therefore assumed that the poplar tree grew in proportion to the birch tree. Using this assumption can you further help Suzy to find the height of the poplar?

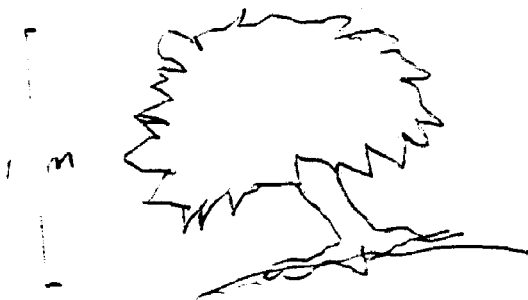
Thus, design a method and explain how you would overcome the problem showing how you arrived at your answer.

Direct Proportion

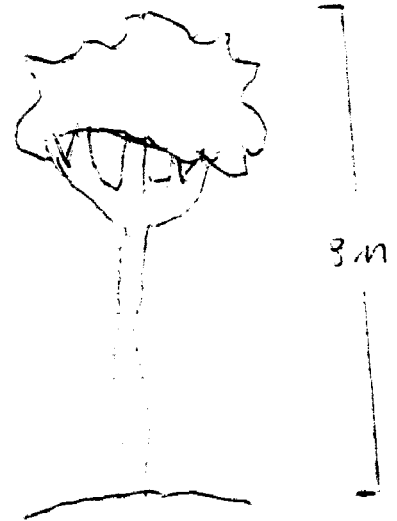
Consider the following experiment conducted by Suzy.

BEFORE:

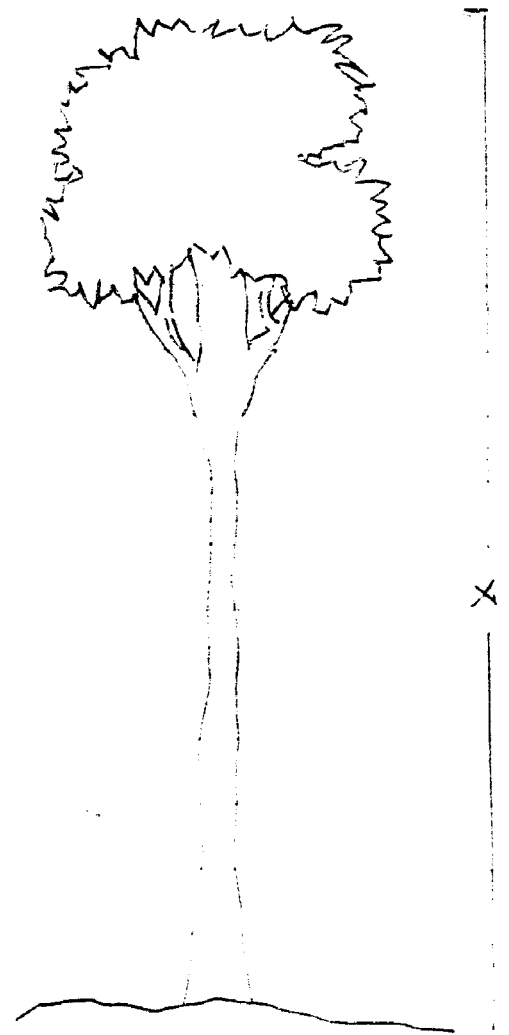
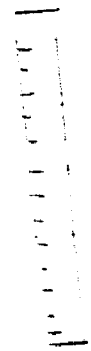
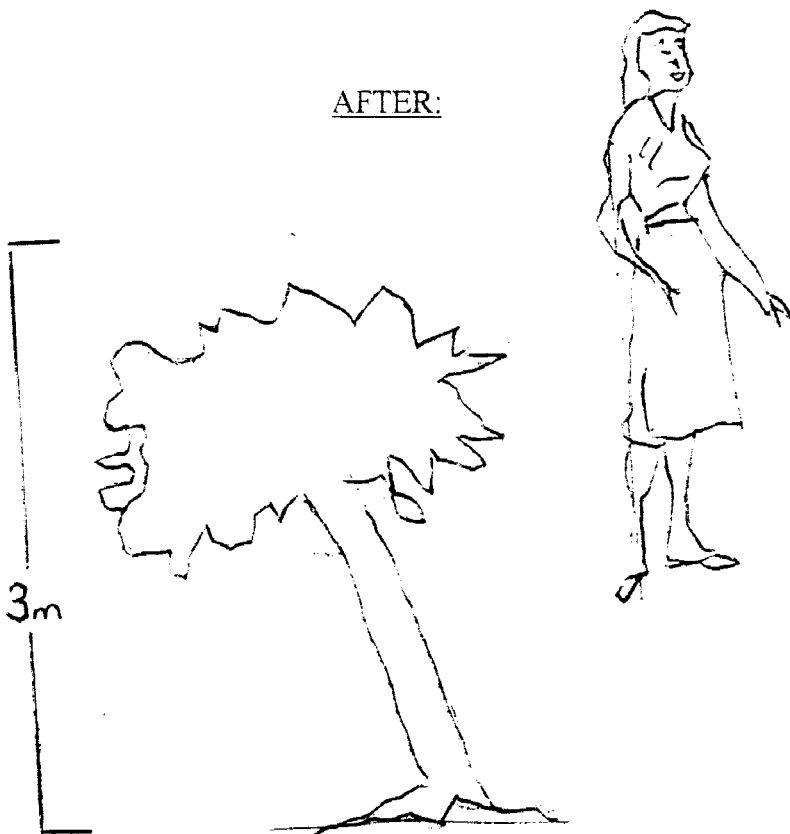
BIRCH TREE



POPLAR TREE



AFTER:



A more standardized method

Do the examples with your teacher

- (1) A learner produces about 65 calories of heat per hour while sleeping. How many calories does the learner produce if he sleeps from 22h00 to 06h00?

- (2) Try this example on your own

An office clerk produces about 170 calories of heat per hour while sitting at her desk. How many calories does she produce during an 8-hour working day?

Direct Proportion Exercise

Try these examples for size

- (1) Under normal conditions, your heart beats about 72 times every minute. About how many times does your heart beat during:
 - a) 60 seconds?
 - b) a 24-hour day?
 - c) a 365-day year?
 - d) an 80-year lifetime?

- (2) The mass of an adult is about 30 times the mass of his brain. If the mass of a man's brain is 2,5kg, what is the mass of his body?

- (3) The body of a 160kg man consists of about 105kg oxygen, 29kg carbon, 16kg hydrogen, while the remainder consists of various other elements.
 - a) how many kilograms of other elements does the man's body contain?
 - b) express, in its simplest form, the ratio between the man's hydrogen content and his total mass.
 - c) express, in its simplest form, the ratio between the man's carbon content and his total mass.
 - d) express, in its simplest form, the ratio between the man's oxygen content and his total mass.

Module Assignment

For this assignment : measurement, equations and ratio and proportion are all skills which you will find useful.

The challenge is to determine the height of rugby goal posts without actually climbing up the posts and physically measuring them.

The only clue which I will give you is this small extract from: P. May's book: *Teaching Children through the Environment* (page 214).

The height of a tall building or a tree can sometimes be measured on a sunny day by using the principle of ratio. A stick is planted in the ground and the shadow it casts is measured. Suppose the stick protrudes one metre above the ground and its shadow is two metres long. This gives a ratio of 1 to 2, and it will be the same for lamp-posts, tower-blocks or oak trees, provided that their measurements are taken at the same time of day as those of the stick. Their heights, too, can then be calculated.

Instructions:

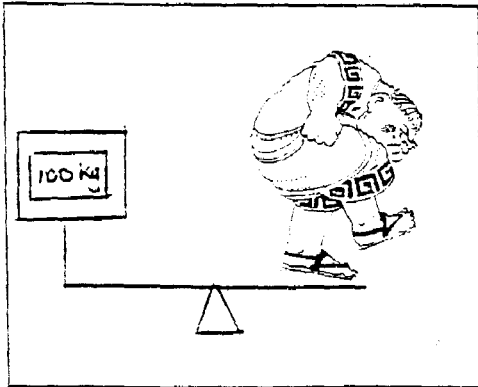
- (1) Form your working groups.
- (2) Go to the rugby field with note pads, calculators and metre rules in hand and determine the height of the rugby goal posts.

Reference consulted for module:

- (1) Bateman, R., & Lidstone, P. (1984). *Steps in Science (Book 1)*. Lockhampton: Stanley Thornes.
- (2) Burkman, E., Darrow, S.P., Redfield, D.D., & Snyder, W.R. (nd). *The natural world modules: Resource book*. New Jersey: Silver Burdett Company.
- (3) Mays, P. (1985). *Teaching children through the environment*. London: Hodder & Stoughton.

Mass, Volume & Density

MASS



From your previous work:

Take a look at the diagram above and explain: What is mass and what are its units?

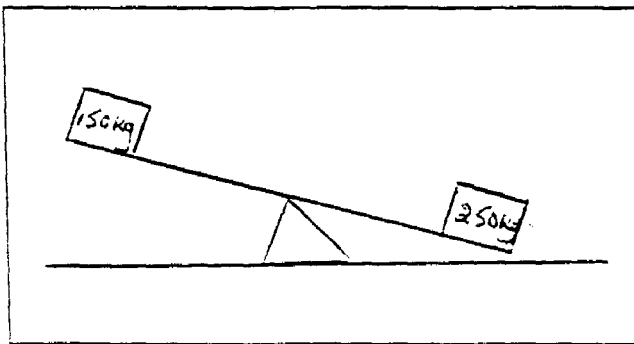
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Consider the beam:



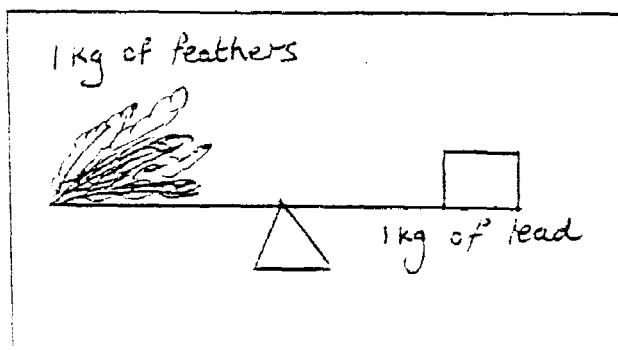
What do you notice?

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What will happen to the see-saw below?



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.....

Volume and its units

Consider the giant white cube at the front of the class. The walls of the cube enclose a certain space. What do we call this space?.....

How can we find the size of this space?.....

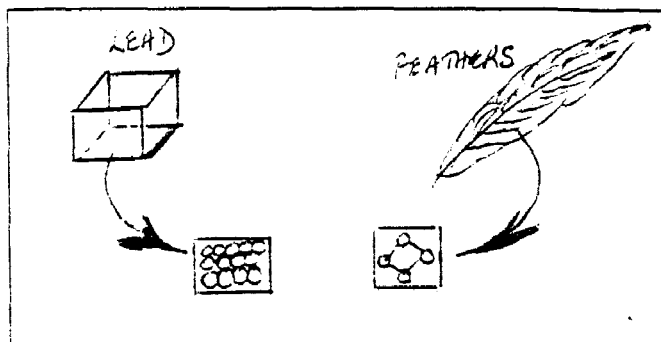
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DENSITY

Introduction

In the previous section on mass and volume you noticed that 1kg of feathers on one side of the see-saw will be balanced by 1kg of lead on the other side. The difference, however, is that a 1kg bar of lead would be about the size of a bar of chocolate whereas 1kg of feathers would fill a huge pillow.

The lead packs its 1kg mass into a much smaller volume than the feathers. We say that lead is more *dense* than the feathers.



In your own words can you describe what is density?

.....

.....

.....

Definition of Density

This means in equation form:

Units of density

The SI (System International) unit of *mass* is the *kilogram* while the SI unit of *volume* is the cubic metre (.....). The SI unit of density is a combination of the two, namely,

For convenience, we tend to use the *gram* as the unit of *mass* and the cm^3 as a unit of *volume*.

Thus, if density is mass per unit volume, it follows then that density speaks of what mass of substance (how much matter) is there in a certain volume. For example, if mercury has a density of 13 g/cm^3 then explain what this means?

.....

.....

.....

DENSITY AND A STUDY OF THE PROCESSES OF SCIENCE

During the course of this lesson and the next we will have an opportunity to engage in science experiments exploring the concept density. In addition, we will learn how to go about doing an experiment and a method to record results.

DEMONSTRATION AND CLASS DISCUSSION

The teacher will show you a number of objects at the front of the classroom. These objects will be placed in water. Some will sink while others will float. Try to decide why these objects are behaving the way they do.

EXPERIMENT: WHY DO SOME OBJECTS SINK WHILE OTHERS FLOAT?

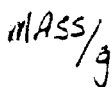
Divide yourselves into groups of three. Go to a work station and determine the densities of the objects which you are provided with. Name these objects and find experimental information which will assist you towards determining the densities of the objects. Establish in the process whether or not the objects will sink or float.

A particular challenge which you may find interesting is to find the density of water as well. The other objects you have been dealing with are all solids. Water is a liquid. Can you think of a way to find its density? (It is no good trying to displace water with water).

During your experiment you will have to decide on a method to record your information so that it is concise and easily interpreted for the purposes of calculation. This is the process skill of *recording* which scientists use extensively.

	MATERIAL	MASS/g	VOLUME/ cm ³	DENSITY/ gcm ⁻³	SINK OR FLOAT?
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					

When you have done this discuss with your group what the results are possibly showing. From these results can you explain why some objects will sink while others will float in water?



Water and density in nature

The following article is adapted from *Flexing hydrogen bonds help water bend the rules*. It was reported by Jeff Hecht in *New Scientist* of 2nd March 1996. The article explains how density and water combine in a very unique way making life in aquatic environments in northerly climates possible.

Water is the most familiar liquid on Earth, but also one of the most mysterious in that ice (the solid form of water) floats on water which is a liquid. Most solids are more dense than their liquid forms.

This property of ice floating on water say researchers at Texas Tech University in Lubbock, may be attributed to the fact that water expands as the temperature drops from 4°C to freezing (at 0°C). What do you think this does to the density of water from 4°C to 0°C ?

Most liquids expand as they become warmer. Above 4°C , water behaves in the same way. Yet the strange reversal of this behaviour that occurs near the freezing point of water is very important to plant and animal life in water. If cold water was not more dense than ice, ponds and lakes would freeze solid from the bottom, rather than evidence a floating layer of surface ice. Hence, life forms in ponds, rivers and lakes in winter-time in colder climates would not be possible.

Water has several other peculiarities. It remains liquid at much higher temperatures than comparable substances and unlike other liquids, it is not as thick (viscous) at high pressures.

ASSIGNMENT

Explain in your own words:

- (1). Why does ice float on water?
- (2). Why is this extremely important for animal/plant life which live in a river in a cold country like Canada in mid-winter?

Your answers for (1) and (2) combined must not exceed a page of average hand writing.

The total for this assignment will be 25. The criteria can be negotiated with your teacher.

.....

Density and Calculations Concerning Density

General Comment

In the last two periods we have been discussing the concept of density. An experiment has been performed and you have had the opportunity to do the write-up.

The important idea is that:

if a body is of small mass and large volume then the density is

If a body is of large mass and small volume then the density is

Scientists tend to relate mass, volume and density in terms of an **equation** or **formula**. This helps them summarise the concept of density very concisely.

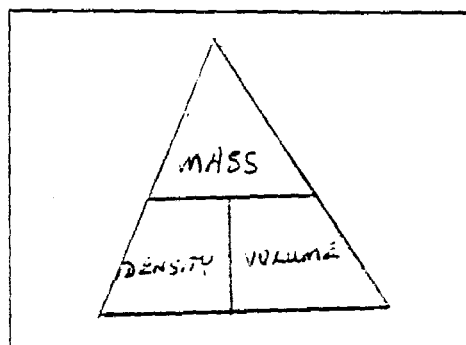
The density formula is therefore given by:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Example illustrating the use of this formula:

Calculate the density of glass if the mass of a glass cube is 67,5g and has a volume of 27cm.³

The approach we have just used is perfectly well and good until we know the density and volume, say, but are asked to find the **mass**. This means that you must make **m** the subject of the formula. To assist you, I have developed a little device which we will call a **memory triangle**.



Further examples:

- (1). The density of sea-water is $1,026 \text{ g/cm}^3$. Calculate the mass of a 1000cm^3 of sea-water.
- (2). The mass of a piece of wood is 27g and its density is $0,54\text{g/cm}^3$. Calculate the volume of the piece of wood.

Exercise:

- (1). Calculate the density of sulphur if 12cm^3 of it has a mass of 24g .
- (2). Calculate the mass of 40cm^3 of copper if its density is 8.9g/cm^3 .
- (3). A rectangular silver block is 30mm in length, 20mm in breadth and 10mm high. Its mass is 63g . Calculate the density of silver.
- (4). The mass of an empty glass beaker is 51.3g . With 50ml of paraffin in the beaker, the mass is now $93,9\text{g}$. Calculate the mass of the paraffin and then its density. **Hint:** $1\text{ml} = 1\text{cm}^3$.

CHALLENGE

Explain in no more than a couple of paragraphs why *ice* floats on *water*.

Grade 8 Test: Density

Instructions

Attempt all the questions including the bonus question at the end.

Question 1

Consider the table of densities of materials:

Material	Density
empty space	0g/cm^3
polystyrene	0.1g/cm^3
cork	0.2g/cm^3
wood	0.6g/cm^3
water	1g/cm^3
stone	3g/cm^3
iron	7g/cm^3
lead	11g/cm^3
gold	19g/cm^3
osmium	23g/cm^3

- (i). How dense are you? Make a guess, remembering that you just float in water. (1)
- (ii). Write down which of the following you would expect to float in water: gold, cork, iron, wood, orange peel. Explain why. (8)
- (iii). Mercury is a shiny, runny metal with a density of 13g/cm^3 . Explain in your own words what 13g/cm^3 actually means. (4)

Question 2

During an experiment a friend of yours shouts out: "A dense thing is where a *small* mass is crammed into a *large* volume."

In a couple of short sentences mention what you will say to your friend in response to his statement. (5)

Question 3

Do the following calculations. You will need your calculators.

- (i). Calculate the mass of 40cm^3 of copper if its density is 8.9g/cm^3 . (5)
- (ii). The mass of an empty glass beaker is 51.3g. With 50ml of paraffin in the beaker, the mass is now 93,9g. Calculate the mass of the paraffin and then its density. (7)

Question 4: Bonus Question

Read the following story and then answer the question which follows:

Once upon a time there was a Greek scientist who liked to think in the bath. His name was Archimedes (say "Arkymeedeez"). He lived in Syracuse, and because he didn't have a bath of his own he used to go along to the public baths in town.

One morning he sat there worrying. The king had come to him the night before with a problem. "Arky, you're a bit of a genius. You keep inventing pumps and things. How can I find out if my new crown is pure gold? I gave the royal crownmaker a block of pure gold, but I think he may have pinched part of the gold and mixed in some of the other metal to make up the mass. How can I find out? Better still, how can *you* find out?

He wasn't as dense as he looked...

Archimedes scrubbed the back of his neck, deep in thought and soapy water. He could measure the mass of the crown. He could borrow from the king a block of pure gold of the same mass. Now if the crown were pure gold it would have the same volume as the block.

He could easily measure the volume of the block. But how could he possibly measure the volume of the fancy and elegant crown? And then he did something skullbendingly brilliant...

...He dropped the soap.

Questions:

- (1) How did dropping the soap help Archimedes solve the problem of finding the volume of the crown? (3)
- (2). Describe an experiment (using modern laboratory equipment) to determine the density of the crown. (4)

Total: 30 marks

APPENDIX D

Sample of learner assignments from “Science & Scientists” lesson unit.

Week 1: Introduction

Science

A fine sketch.
I'm impressed. Kabele.



- ① In science I think we are going to learn about living things like trees, plants, human beings and animals. But I think it is not only about living things, and we learn how to do chemistry, and lots of scientific things. What I think about science is that science is all around us.

Good ... Do you think that you are the one who applies scientific thought and action in everyday life? If so, how?

This may be
A 2. Science is ~~not~~ one of my ~~greater~~ ^{you will know} subjects but I like seeing things happen. I am hoping to do my best in Science. I like working with things like atoms and molecules etc. I like working with chemicals to. I do not like really working in science because I am more ~~into~~ into the other things. I like how the setup of the classroom has been done. I find science quite interesting.
Thank Dr Kees.

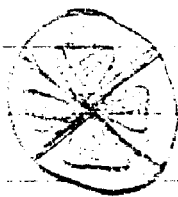
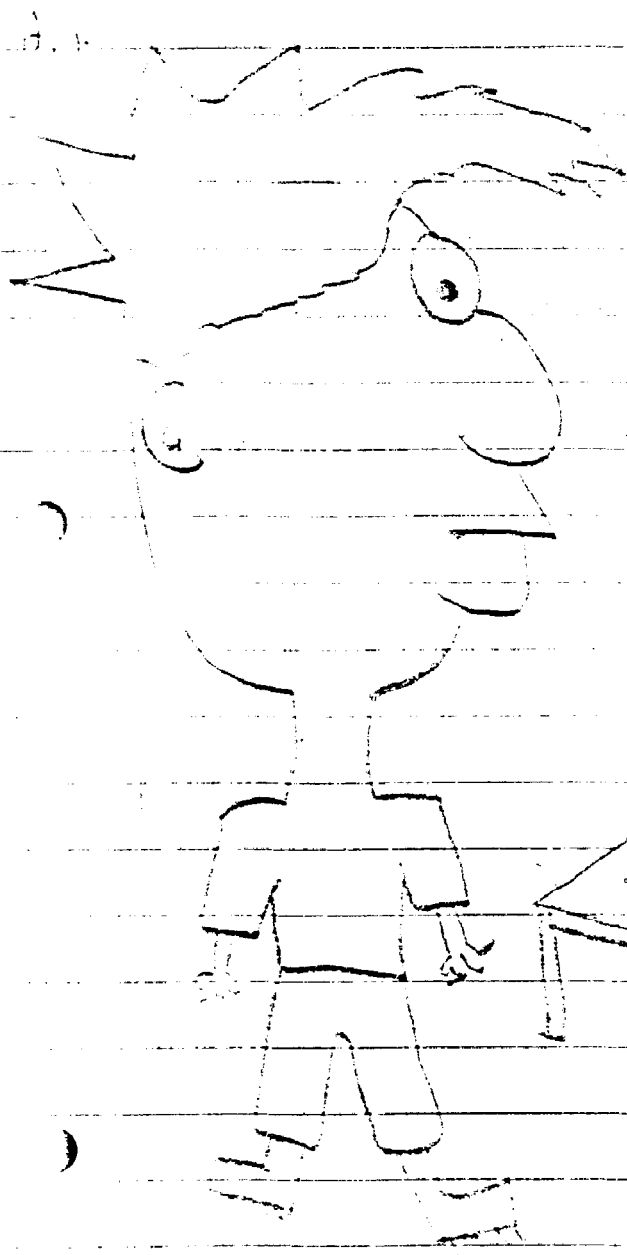
As Albert Einstein and James Radulf

Yours truly
A. Einstein

M. Morgan

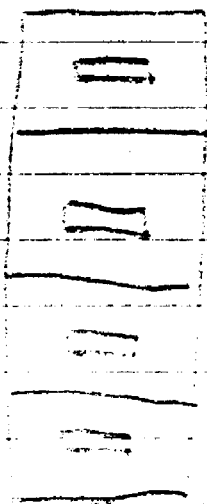
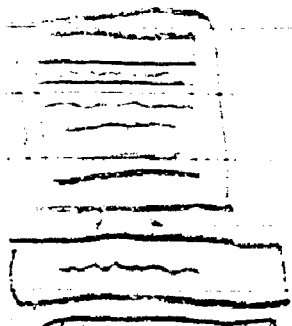
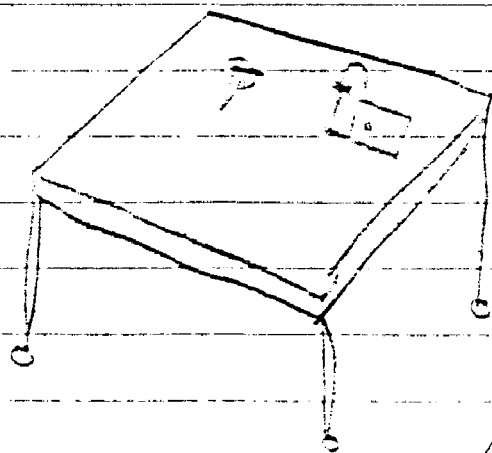
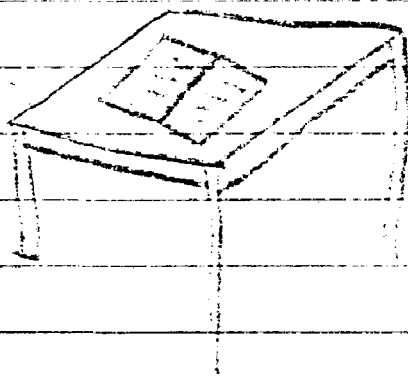
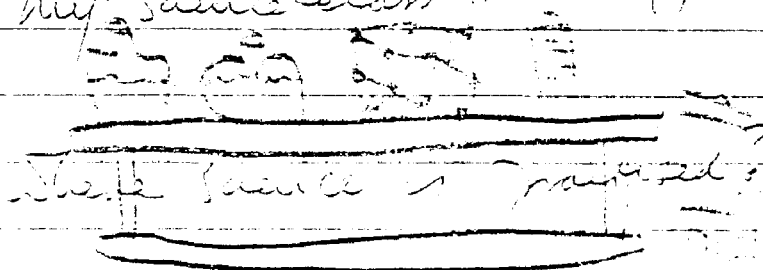
Science Test

27/1/98



THAT WAS TEST
BUT WILL YOU

Matthew — I am good
drawing — I can
my science class in any place



A line drawing of a mechanical component, possibly a valve or a part of a machine. It features a central circular opening with a smaller, concentric circle inside. The component has a rectangular base and a curved, flange-like top. The drawing is simple and schematic, with no shading or texture.

10-10-50

What is the scientific meaning of the bottle?

2. I think that Science is ~~linked~~ (and Maths) is linked to almost every other subject around some way or other so Science involves lots of things. Chemistry is the most famous part of Science I think because most pictures of Scientists show them with bubbling bottles of liquid. I think that we'd study plants and animals

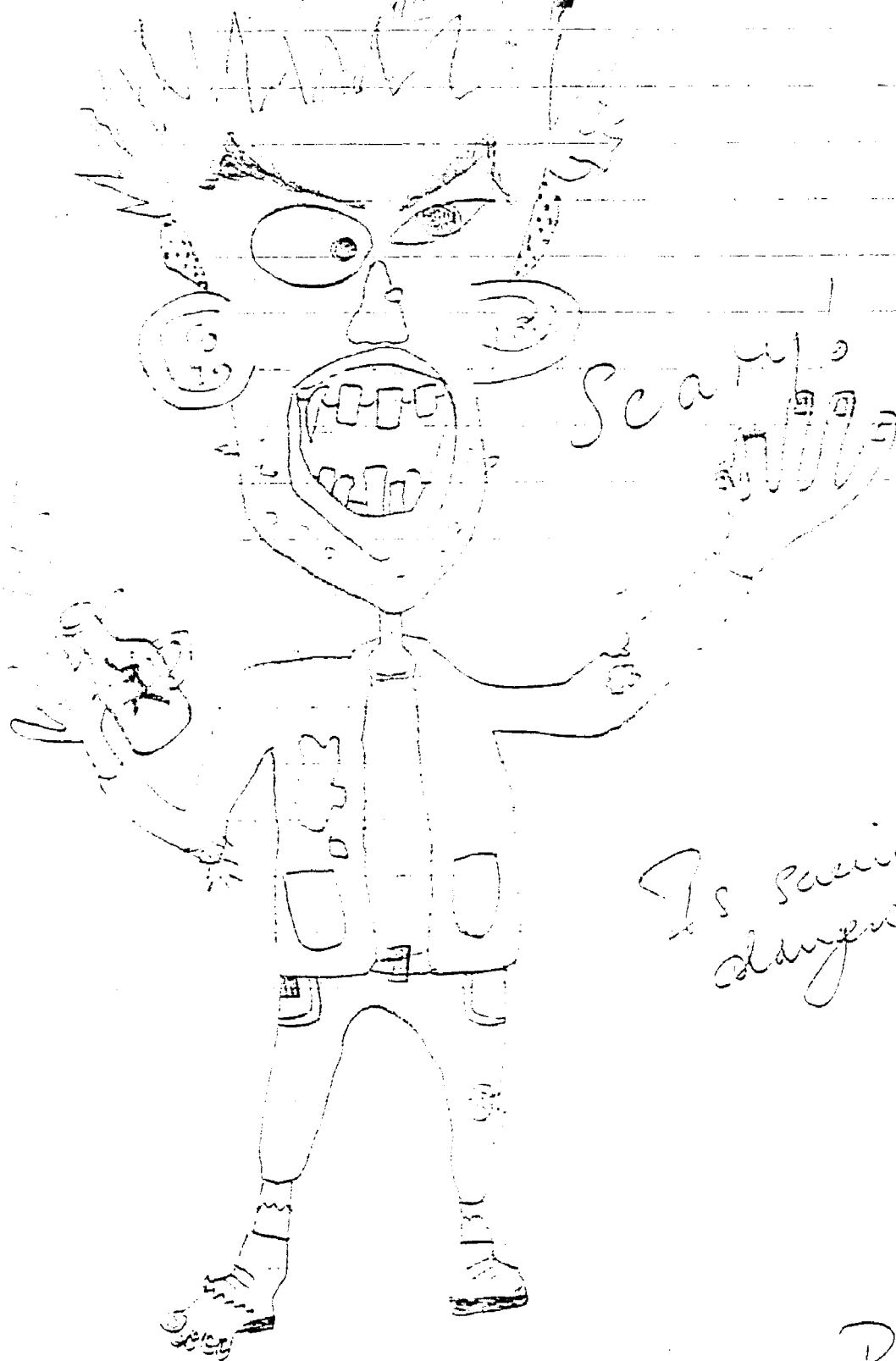
Is this how
you see me
perhaps. --
In any event I
am glad you
are back and
I'll thank you
with us.

W. Armstrong

Science

27 Jan

Assignment 1



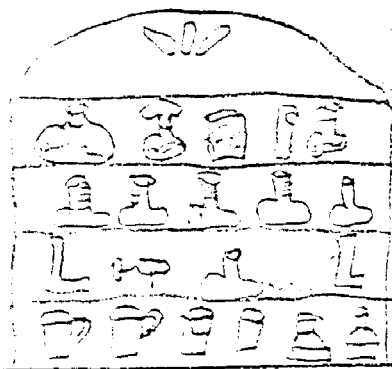
Is science always
dangerous William

Assignment 2

OK! Point to the Do you just
think we are going to
study topics in science?

I think science involves just about everything. It is a part of everything on earth. In class boys and girls study mainly topics that science makes up.

Ben low



An exciting

Science

Science - is ^{the} exploration to find out about human nature, wild life and technology. I think it is to explore chemicals and to experiment with specific chemicals and not know the outcome. It is to be able at the end to know which substance to use to test specific things.

I agree! V.V. good.

3 No because women can also be qualified scientists and some already are, the

A very, very good point. "Science" has many secrets. In our work we will have to predict some outcomes.



Excellent sketch. The sketch you are in white is protective clothing for me parents.

2. I understand that Science is the study of many things. There are a lot of Sciences and they mostly have to do with our lives. Biology is a science and has to do with life. Our plant life, animal life and our life. There are many other Sciences involved, like Astrology, zoology and ethology. In Science we study a lot about the Earth and other planets around it. Space is an essential part to the development of our lives. Science is the evolution of mankind.

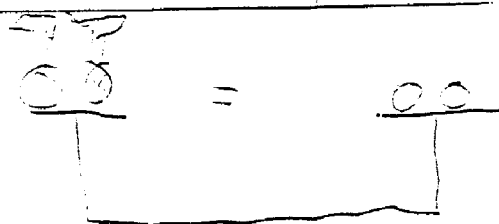
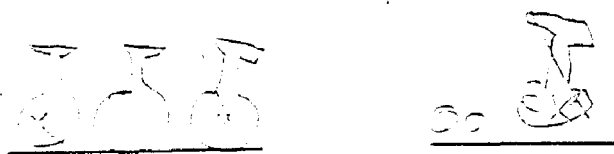
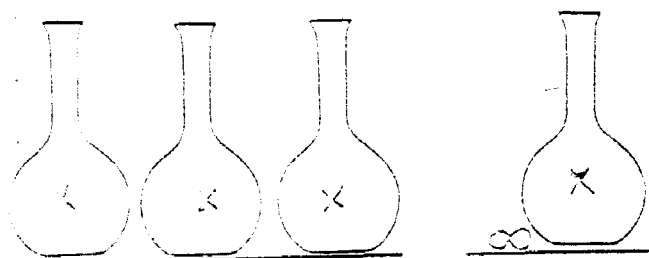
Some nice thoughts Samora.

Not a true science — are you not thinking of Astronomy?

APPENDIX E

Errors in equations and poor presentation.

PICTORIAL EQUATIONS

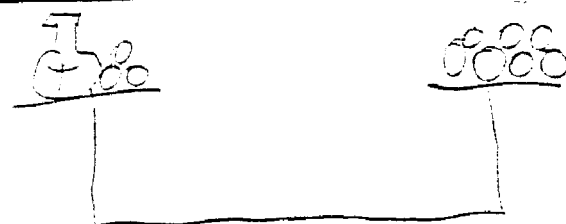
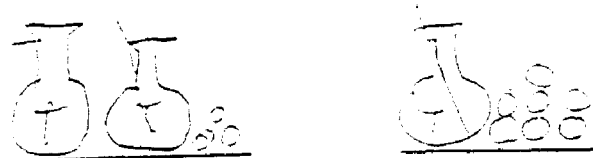
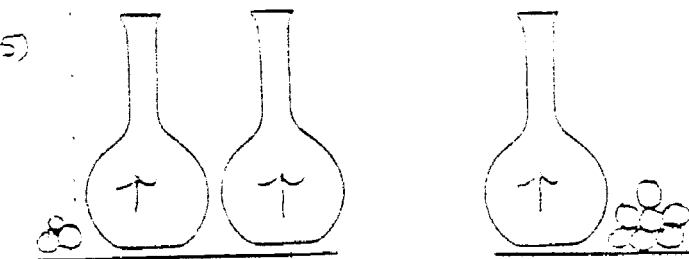


$$\begin{aligned}
 2x + x + x &= 2x + x + x \\
 2xx &= 2x + x + x \quad 2x = \\
 2x + x - x &= 2 - x \\
 x &= 1
 \end{aligned}$$

ALGEBRAIC EXPRESSION OF EQUATIONS

PICTORIAL EQUATIONS

(5)



$$\begin{aligned}
 3 + T &= 3 + T \\
 3T &= 3 + T \\
 3 + T - T &= 3 - T \\
 T &= 4
 \end{aligned}$$

ALGEBRAIC EXPRESSION OF EQUATIONS

APPENDIX F

Science Test I Contributions

How it has influenced our culture

You can see the way science influences our culture by merely looking around. For example, (I am in the science room) I look around and see gas taps. In the old days, you would probably have to go to a mine to find gas, now we can use quickly because it is right here at our fingertips. If you didn't have a gas stove at your kitchen, our culture would be different. *(Most modern home as it has gas stoves)*

In the stone-age science influenced man's culture, ~~but~~ because of the way they ~~experimame~~ experimented with stone (this being science) and found a way to use stone and metal to their advantage, changing their culture completely. *completely*

Because science has developed so much in the last few years, my culture has also changed a lot. For example, without a creepy-crawlie (a device for cleaning a swimming pool) we would take ten times as long to clean the pool and also ten times as much effort and energy.

Science has influenced everyones culture at least in more than five ways. Every body uses science every day without knowing it, and in doing so, changed their culture. So therefore I conclude, science has influenced our culture in almost every single little way possible. Without science, we would be lost.

IN WHAT WAY DOES

SCIENCE EFFECT

OUR LIVES

Science has affected our lives in many ways
and I am going to ^{mention} mention only five of them to
you today.

Expt 1:

Science in this case medical science helps us

act in sport because if we didn't have sports
injuries we wouldn't need medical treatment, but as I recall

we do have sporting injuries and there would
be no cricket because of Allen Donald and the
new ^{ways} ~~ways~~ because they get pulled muscles and broke
their fingers but they have things like physiotherapy
which can heal them and the ^{stretches} ~~stretches~~ stuff

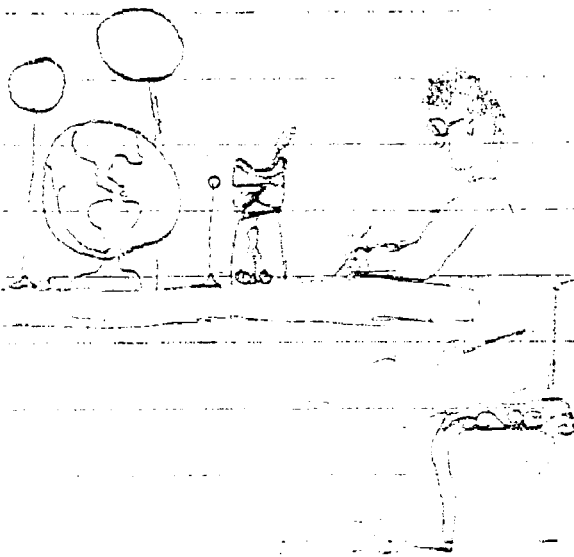
if they put on so you can carry on with living
like yesterday with that lenth person when
he got hit on the back of the neck and he
had ^{physio} ~~physio~~ done to him

Expt 2:

injured.

We also get badly injured and we can get infected
so biology helps us to find a plant way to cure
the person. The vets need lots of anty antibiotics
to ^{heal} ~~heal~~ ^{accident} ~~accident~~ ^{injury} ~~injury~~
and distresses. For car accidents we need to know
how long ago the accident happened. Why?

Indy Biehn



A neat sketch.

Indy

Think about the element intellect.
You will see a cinema - see mission impossible
that a science activity.

I understand the subject Science to be the study of
everything in side and out side buildings. You also get
scientist ^{who} invent things by looking around every
day life and design mechanical objects to
make life easier

Same good thought though!

Science has influenced us in many ways such as with stoves instead of ^{fire} ~~fire~~; lights instead of gas lamps. It has made life so much ^{easier} easy. It has also made us ^{healthier} healthier (and ~~the~~) but has ^{polluted} polluted the air and water. It has also killed off some animals. Science has made transport ^{easier} easy with planes and ships and cars ^{however, science} ~~but~~ ^{polluted} ~~polluted~~ the air and land with fumes (and rubber) and ~~also~~ ^{also} oil spills. ~~not with rubber.~~

War

Science has made ^{machinery} machinery for war which has made it much more gory and violent and now all people have guns and that causes lots of violence.

houses:

In the houses it has made life much more comfortable and relaxing. ^{example in our culture, new} ~~such as~~ beds, chairs,

T.V. radios computers and Hifi's. It has also affected the way we dance and the music we listen

why?

How Science Has Influenced Culture.

Science has influenced culture in a way that people ^{now} look back and say they used to live a barbaric life.

Is science the same as technology?

Modern day technology (science) has brought a lot of change into our lives. Some people don't even ^{practice} their ^{cultural} ways anymore because ^{modern} day things which fall under science have made them ~~not~~ think that their culture is barbaric.

Science has also ^{made} ~~gotten~~ people lazy. Nowadays a person never even stands up to close a curtain because there are remote controls to close them, all they have to do is ^{press} a button and the curtain will close. There are also remotes ^{for} ~~of~~ garages, lights, doors and TVs. All these things make people lazy.

There are some ways which science influenced culture, good ways, but science has given a ~~different~~ look at things, but as I have already made myself clear, I think science has a bad influence on culture.

↓
You'll need to explain in what way science ~~has~~ ^{is} good for your culture. To say it is good in some respects is not sufficient.

1. Science has influenced our lives in a miraculous way. We have developed from being savages ^{and} due less cave-men, ~~to~~ ^{to} become intelligent and well brought up human-beings.

→ When we were first nomadic, birth used to be a natural ^{Nomads probably never had one tool in any event.} and dangerous thing, if one was without out the proper tools. Then all of a sudden Science comes into the picture and soon enough we're in hospitals, we've got medical aids and ~~but~~ birth is a lot easier. With Science you don't even have to have intercourse for you to have a baby. You simply give a sample of sperm to a specialized doctor and he plants your sperm inside your wife's egg. Not strictly true.

Looking at sports like Soccer, Rugby, American Football, Australian Rules Football etc you'd expect a lot of injury to occur. Our Science today provides a number of medicines to help the players. For example; in a Rugby game a person gets a cut, deep enough for stitches, on the forehead. As soon as they take him off the field he's back on. It takes about five minutes to stitch up the wound and then he can go back to the game.

Some native cultures have changed in a dramatic way because of Science. In some African ~~cultures~~ ^{circumcisions} ~~circumcision~~ was, and still is, a family tradition. A young boy of 17 is taken to the bush, or veld, and is circumcised with a blunt knife. In the world of today Science makes it possible to get circumcised medically and still live afterwards.

APPENDIX G

Letter

26 February 1998

Dear Parents of Grade 8Z Science pupils

We are always looking at improved approaches to teaching. Last year we decided to implement a pilot scheme in the teaching of Science to Grade 8Z (Standard 6Z) by Mr Warren Wilkinson, a Masters student in Education, who is teaching in conjunction with our own Mr Robinson. Mr Wilkinson is trying to give pupils a better understanding of what Science is and how scientists go about their work and the impact which Science has on society, as well as enabling pupils to conduct their own investigations and developing the appropriate skills.

We are aware that a couple of problems have arisen due to the ambitious expectations of Mr Wilkinson, and these are in the process of being addressed. We are monitoring the situation closely and can assure you that the normal Grade 8 syllabus will be covered by the Grade 8Z class (albeit from a different perspective), so that these pupils may move forward to Grade 9 in the usual way. The marks of Grade 8Z will also be comparable or better in the first term than the other mixed-ability Grade 8 classes.

Mr ROBINSON is involved with Mr Wilkinson in the classroom and will give us continual feedback on the progress of this pilot scheme which will remain under constant review.

Yours sincerely

HEADMASTER

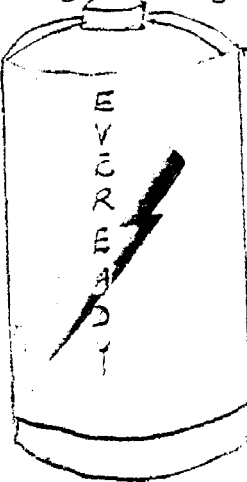
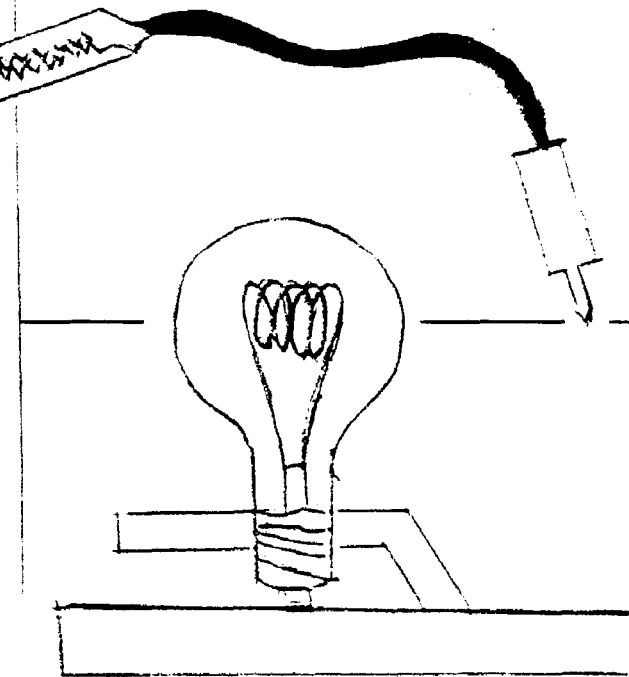
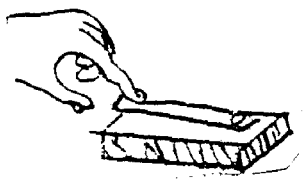
HEAD OF SCIENCE

APPENDIX H

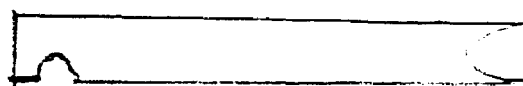
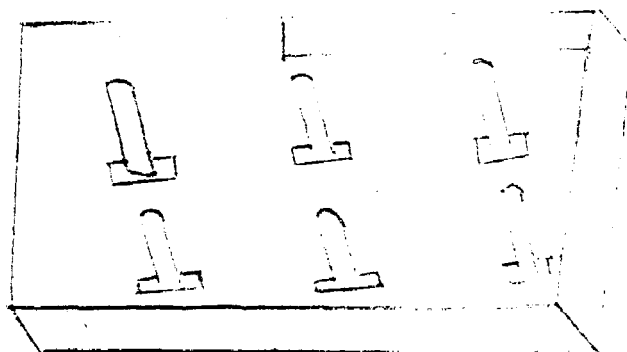
The Grade 8 Course Notes of **Mtunzini**: Parts of an electric Circuit

The parts of an electric circuit: Their names and symbols

See if you can name the following parts and give their symbols

picture of electrical apparat		symbol of electrical apparatus
		
		
		

Picture Of Electrical Apparatus



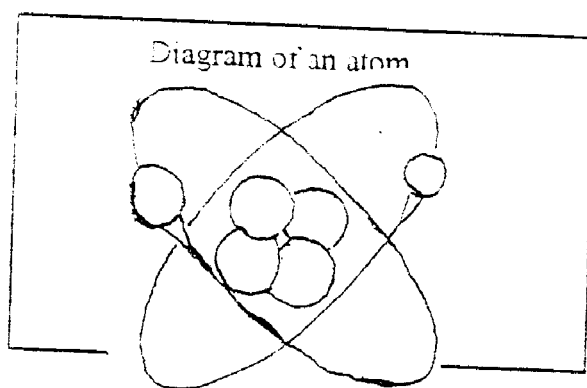
Electricity - Magic at your finger tips

Just think how you used electricity today. Were you awakened by an electric alarm clock? Did your father shave with an electric razor? Did your mother make toast with an electric toaster?

Did you watch television before going to school? Did you ever stop to wonder what makes your doorbell and telephone work?

Think of all the things in the world that electricity makes work, and you will see why anyone might use the word "magic" for it.

Scientists have a theory about the nature of electricity. Before we can understand electricity, however, we must first discuss the make-up of materials such as electric wires. These wires are made up of atoms which are further made up of smaller particles called electrons, protons, neutrons, and many others.



Scientists believe that electricity is made up of electrons that are part of all material. When we get these electrons to move, we have an electric current - electricity.

So what makes these electrons move?

The answer is a power source such as generators or simple torch cells. The electricity - or moving electrons - is pushed through wires and makes bulbs glow, for example.

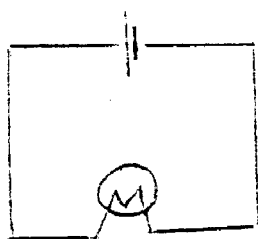
Task

- (1). Name 5 pieces of equipment which use electricity.
- (2). Explain in your own words why a bulb glows when connected in an electric circuit.

Task:

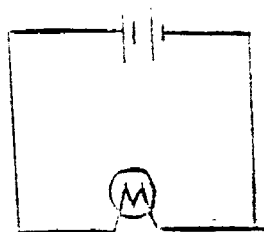
Connect up the following circuits and answer the questions which follow

Circuit 1:



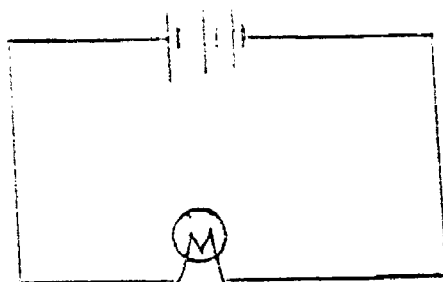
What happens to the globe?

Circuit 2:



Compare to circuit 1 and explain what happens to the globe?

Circuit 3:



Compare to circuit 2 and explain what happens to the globe?

Conclusion:

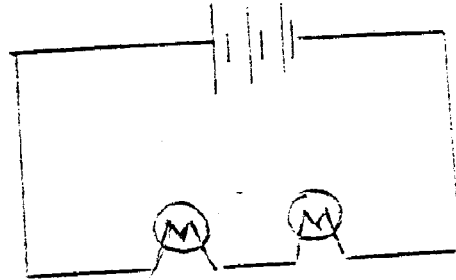
Now explain what makes the globe shine in each case?

Circuits in series and parallel

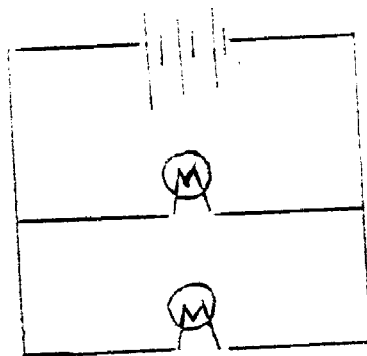
Task:

Connect up the following circuits and answer the questions which follow:

Circuit 1:



Circuit 2:



Questions

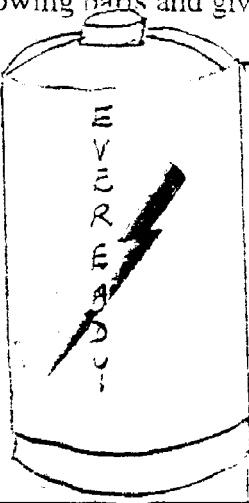
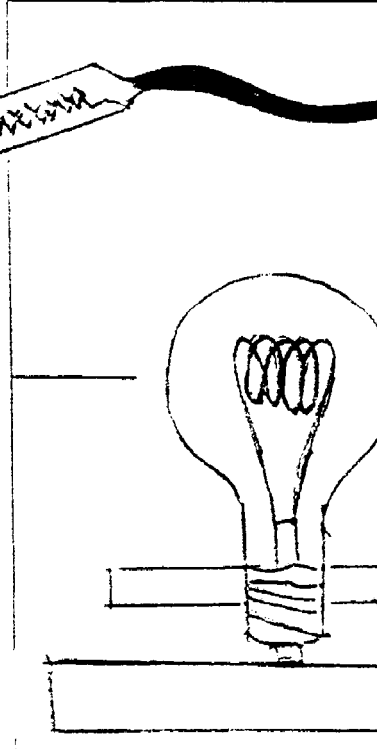
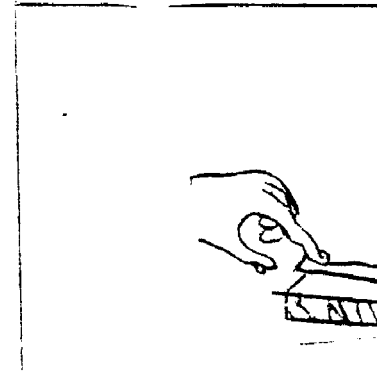
- (1). What do we call circuit 1 and circuit 2?
- (2). In which circuit are the lamps brighter?
- (3). Explain why you think this should be so?

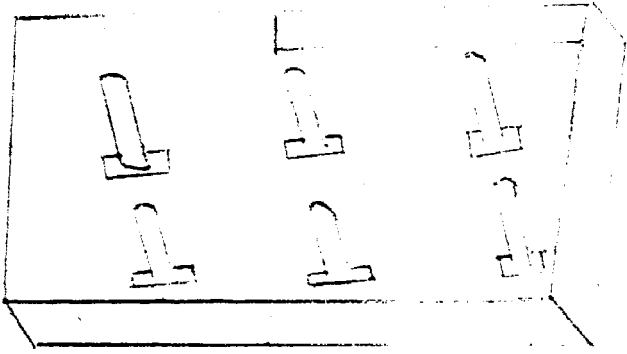
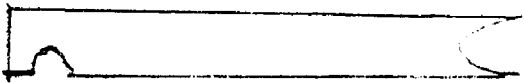
APPENDIX I

Grade 8 Course Notes for Mtunzini

The parts of an electric circuit: Their names and symbols

See if you can name the following parts and give their symbols

picture of electrical apparatus		symbol of electrical apparatus
		
		

Picture Of Electrical Apparatus



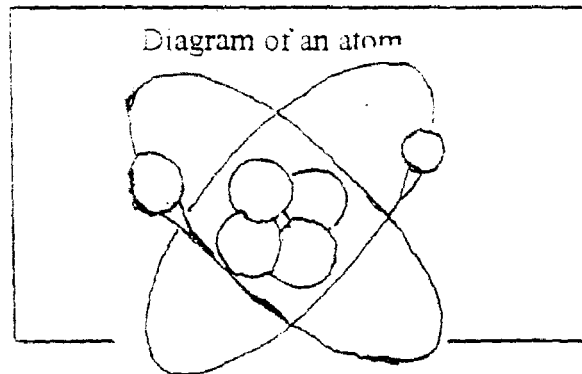
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Did you watch television before going to school? Did you ever stop to wonder what makes your doorbell and telephone work?

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So what makes these electrons move?

The answer is a power source such as generators or simple torch cells. The electricity - or moving electrons - is pushed through wires and makes bulbs glow, for example.

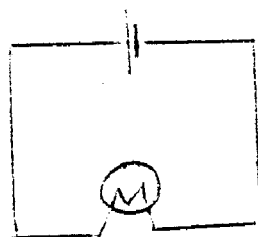
Task

- (1). Name 5 pieces of equipment which use electricity.
- (2). Explain in your own words why a bulb glows when connected in an electric circuit.

Task:

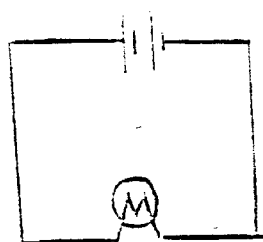
Connect up the following circuits and answer the questions which follow

Circuit 1:



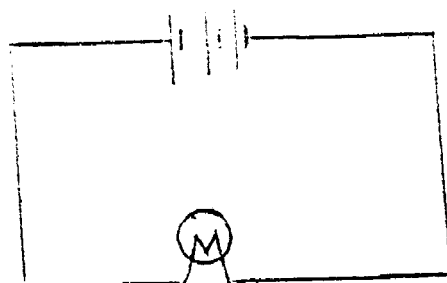
What happens to the globe?

Circuit 2:



Compare to circuit 1 and explain what happens to the globe?

Circuit 3:



Compare to circuit 2 and explain what happens to the globe?

Conclusion:

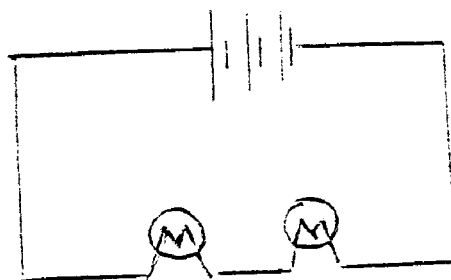
Now explain what makes the globe shine in each case?

Circuits in series and parallel

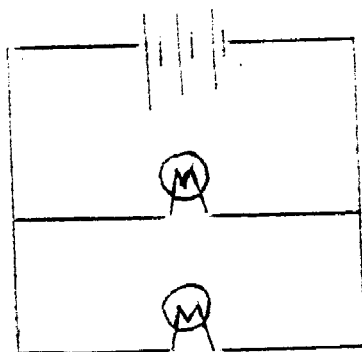
Task:

Connect up the following circuits and answer the questions which follow:

Circuit 1:



Circuit 2:



Questions

- (1). What do we call circuit 1 and circuit 2?
- (2). In which circuit are the lamps brighter?
- (3). Explain why you think this should be so?

Comprehension Test

Read the following passage and then answer the questions which follow:

WHO DISCOVERED ELECTRICITY?

The curious thing about electricity is that it has been studied for thousands of years - and we still don't know exactly what it is! Today, all matter is thought to consist of tiny charged particles. Electricity, according to this theory, is simply a moving stream of electrons in metals.

The word "electricity" comes from the Greek word *electron*. And do you know what this word meant? It was the Greek word for "amber"! You see, as far back as 600 B.C. the Greeks knew that when amber was rubbed, it became capable of attracting to it light bits of cork or paper.

Not much progress was made in the study of electricity until 1672. In that year, a man called Otto von Guericke produced a more powerful charge of electricity by holding his hand against a ball of spinning sulphur. In 1729, Stephen Gray found that some substances, such as metals, carried electricity from one location to another. These came to be called "conductors". He found that others, such as glass, sulphur, amber, and wax, did not carry electricity. These were called "insulators".

The next important step took place in 1733 when a Frenchman called du Fay discovered positive and negative charges of electricity, although he thought those were two different kinds of electricity.

But it was Benjamin Franklin who tried to give an explanation of what electricity was. His idea was that all substances in nature contain "electrical fluid". Friction between certain substances removed some of this "fluid" from one and placed an extra amount in the other. Today, we would say that this "fluid" is composed of electrons which are negatively charged.

Probably the most important developments in the science of electricity started with the invention of the first battery in 1800 by Alessandro Volta. This battery gave the world its first continuous, reliable source of electric current, and led to all the important discoveries of the use of electricity.

Questions

- (1). What is **electricity** considered to be according to the latest theory?
- (2). *Electron* is a Greek word. What does it mean in English?
- (3). Who produced a more powerful charge of electricity by holding his hand against a ball of spinning sulphur?
- (4). What did Stephen Gray discover in 1729?
- (5). Who discovered the existence of positive and negative charges of electricity and in what year?
- (6). Benjamin Franklin tried to explain electricity in terms of "fluid" which was transferred from one substance to another when they were rubbed together. According to this passage what is this "fluid"?
- (7). Who discovered the battery?
- (8). Give the meaning of each of the following words which appear in the extract:

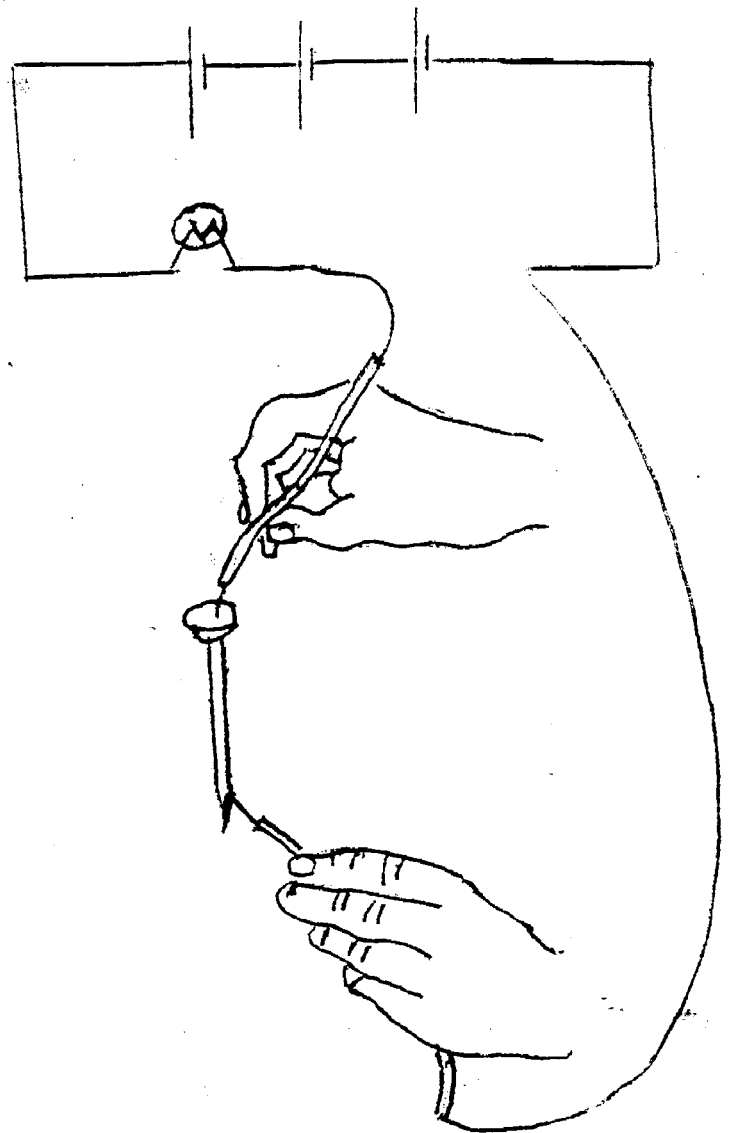
stream, bits, conductors, different, substance, composed, invention.

Total [15].

Conductors and Insulators

In your group, decide what is meant by a “conductor” of electricity and an “insulator” of electricity.

Now do the following experiment. Connect up the circuit shown below:



Does the light shine? _____

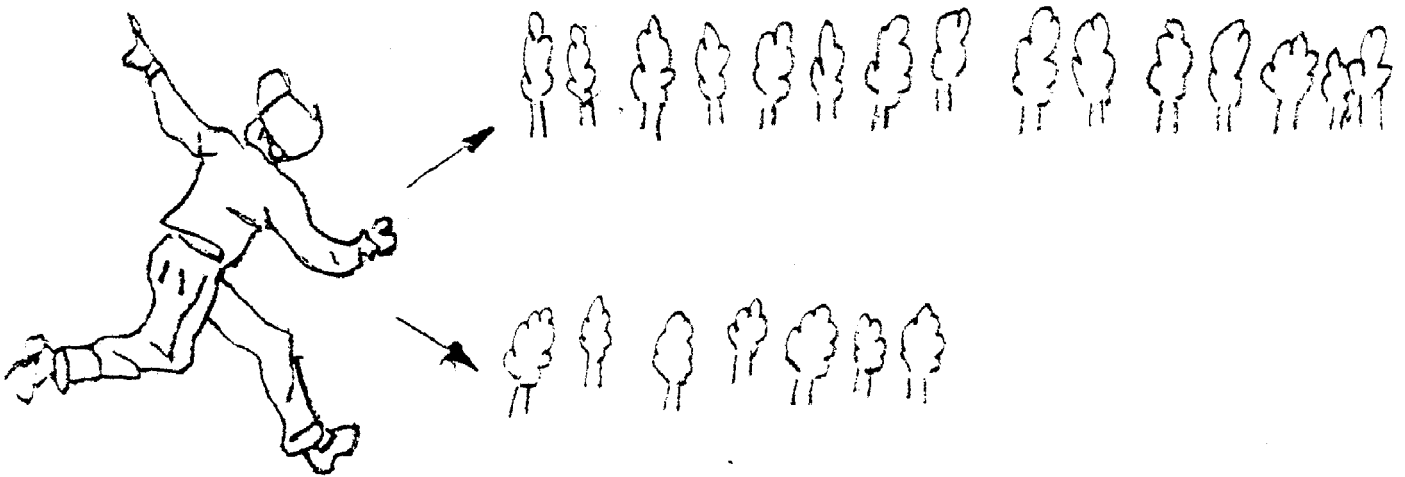
What does this tell you? _____

Now do the experiment again, but use a piece of wood, copper, plastic straw and lead, for example and **record** your results. What does “record” mean and how are you going to do it? Decide among yourselves.....Don’t start by asking the teacher.

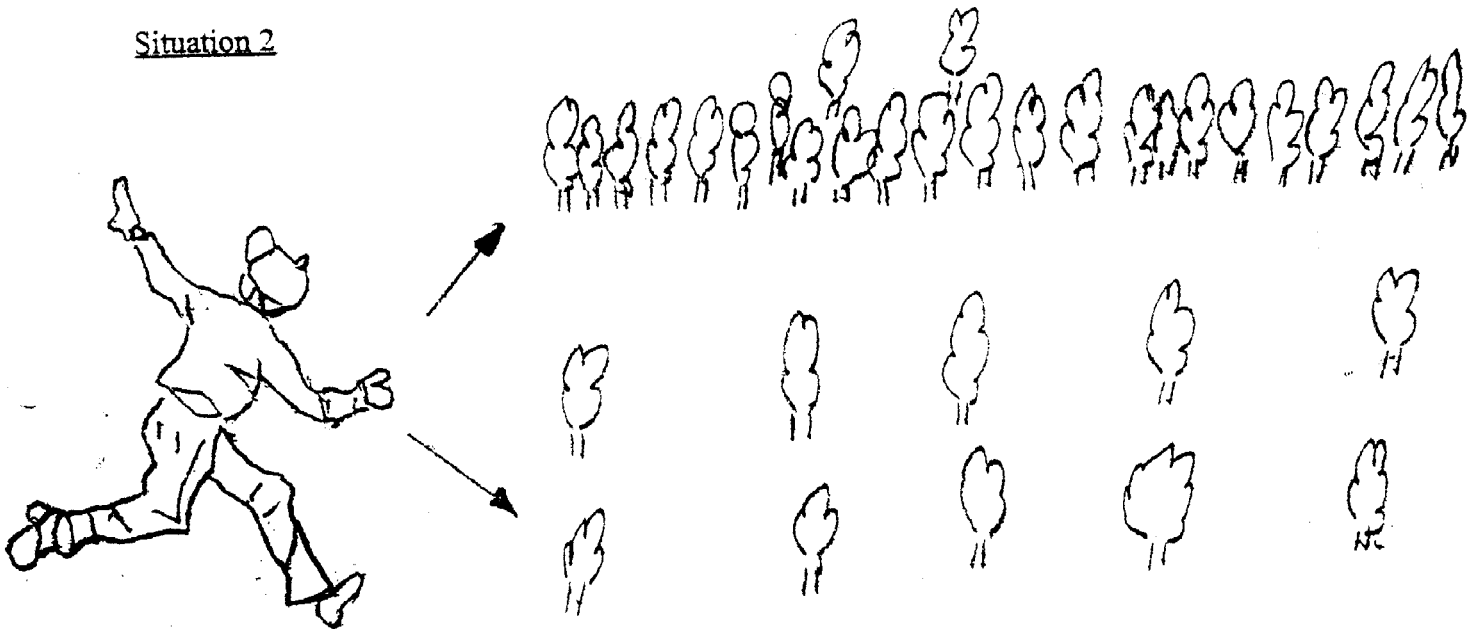
Resistance

Consider the following sketches:

Situation 1



Situation 2



Which forest should Tombi run through to have the easiest trip home? Discuss why in your groups.

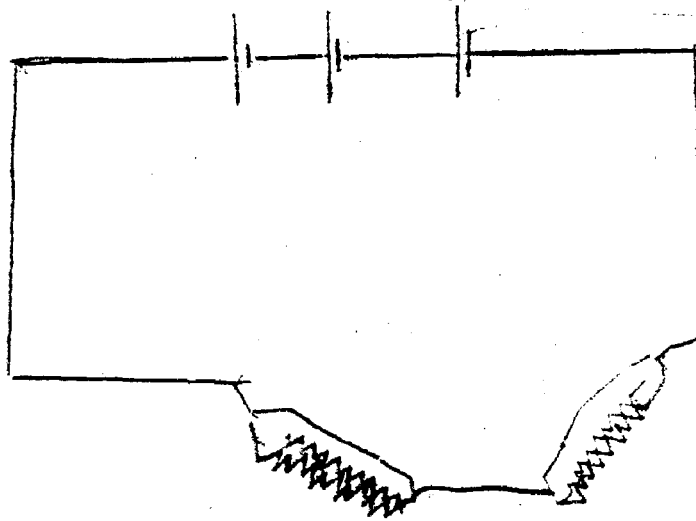
Thus, what do we call this **opposition to movement**?



Resistance

Task

Connect up the following circuit:



After a minute put your finger on the nichrome wire. What do you notice?

Do you think nichrome has a high resistance or a low resistance? _____

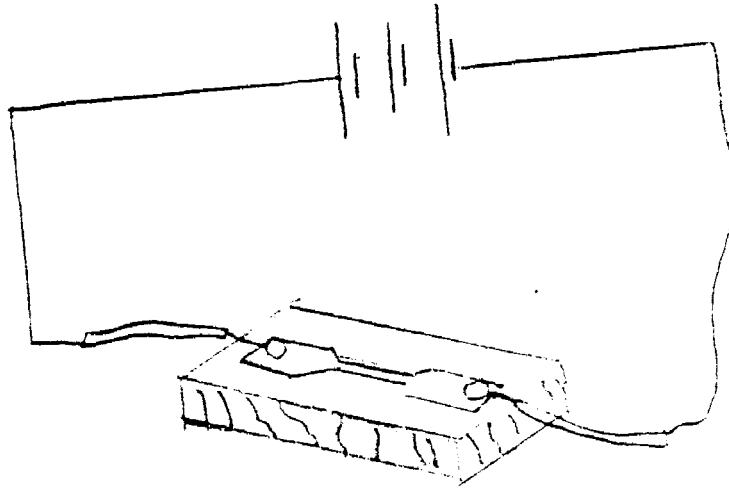
Explain: _____

Do electrical appliances, for example, toasters, kettles and irons, have a high resistance or a low resistance? _____

Explain: _____

The fuse - "The policeman of electric circuits"

With a thin sheet of tin foil connect up the following circuit:

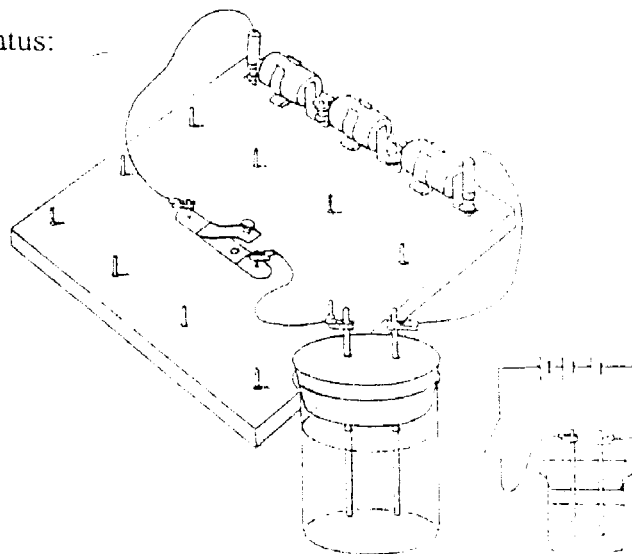


After a short time, what do you notice?

Can you explain it?

The chemical effect of an electric current

Set up the following apparatus:



Add some copper chloride to a beaker of **distilled** water and stir until all of the copper chloride is dissolved. Then place the carbon electrodes into the electrolyte (the solution of copper chloride) and connect up the circuit as shown.

Say what happens at the electrodes and describe what happens to the globe:

Discuss the results amongst your group and then try and come up with an explanation to account for your observations. To add to your explanation you may wish to read the following extract taken from a grade 10 textbook on electrolysis.

Discussion

When the current is switched on, small *gas bubbles* can be seen at the graphite rod which is connected to the positive pole of the battery. (We call this graphite rod the *positive electrode*.) From the smell we can tell that the gas is *chlorine*. (The smell of chlorine is often observed at swimming pools and in drinking water where it is used for purification of the water.)

After a few minutes a *reddish-brown solid* is formed on the graphite rod which is connected to the negative pole of the battery. (We call this graphite rod the *negative electrode*.) The reddish brown solid is *copper* metal in powder form. Often the copper turns black as a result of a second reaction which takes place.

By passing an electric current through a solution of copper chloride, the copper chloride is

broken up (decomposed) into its parts, namely copper metal and chlorine gas.

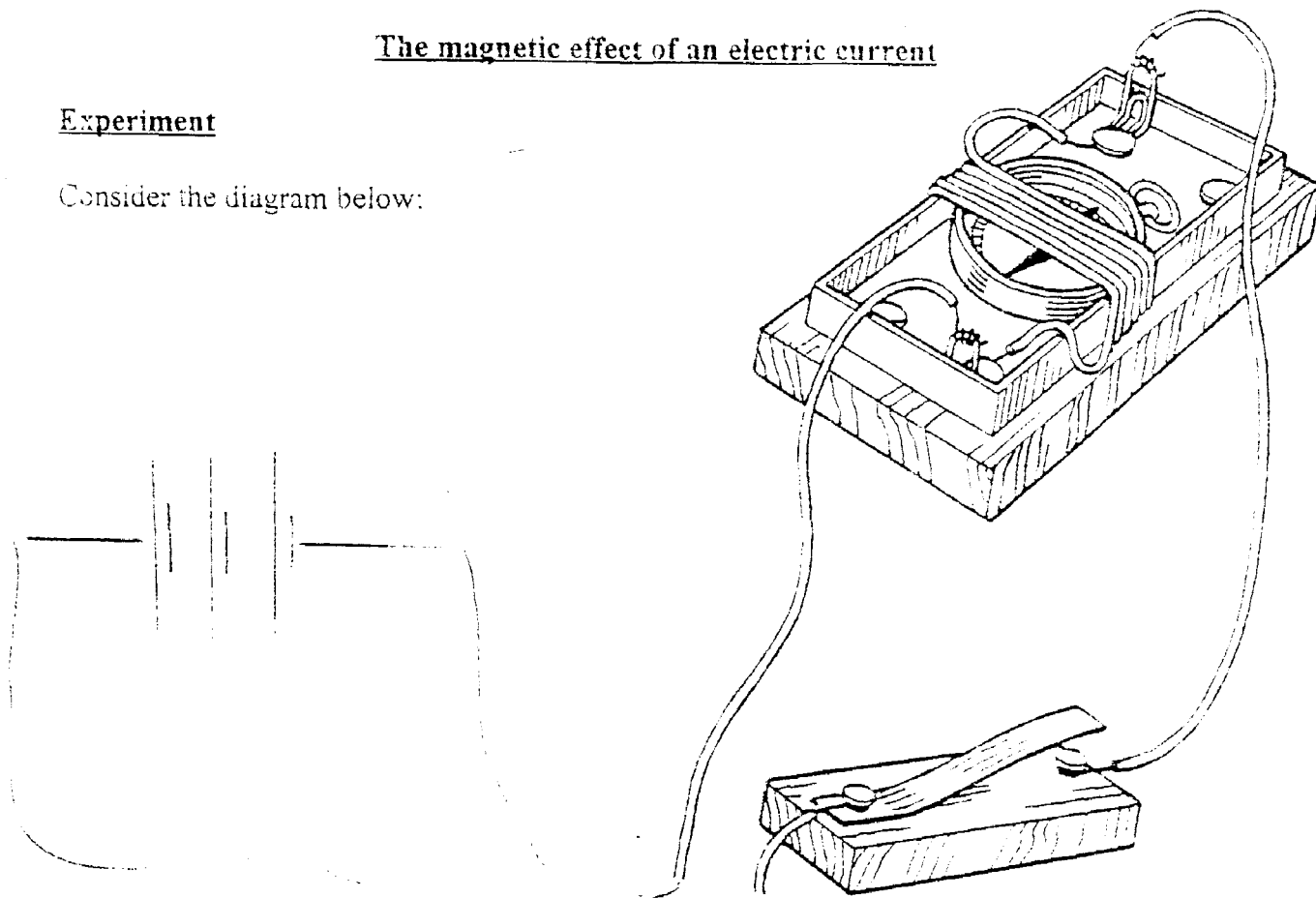
When an *electric current* is passed through a copper chloride solution, a *chemical reaction* takes place. This is known as the chemical effect of an electric current. During this process, *electrical energy is transformed into chemical energy*.

When a chemical reaction takes place as a result of an electric current, the process is called *electrolysis*.

The magnetic effect of an electric current

Experiment

Consider the diagram below:



When the switch is pressed what do you think will happen to the compass?

DO the experiment to see if your prediction was correct.

Generation of Electricity

We have seen that a wire carrying an electric current has a magnetic field around it. Alas, it is also true that a moving magnetic field can produce an electric current. Can you **design** an experiment to prove this.

When you do your write-up it must come in the following way:

- * Heading for experiment
- * Aim of experiment or investigation
- * List of apparatus used
- * Diagram of apparatus used
- * Method of how you did the experiment
- * Results and observations
- * Conclusion (which usually answers the question presented in the aim part).

Maybe you will not know where to begin. Scientists are often in your position. They then go down to the library and find out.... This is where you will go to become better informed.

1

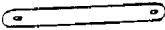
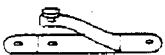
Grade 3 Science Test: Electricity

NAME _____

Answer all questions in the spaces provided.

Question 1

Write the **symbols** for each electrical part shown

NAME	SKETCH	SYMBOL
Torch cell		
Connector		
Switch open		
Switch closed		
Lamp		

[5]

Question 2

Choose, by marking the correct word(s) from those given in brackets.

For example: The **main** function of an electric cell is to give (heat; an electric current; sound).

(a). Which of the following would you **not** normally find in an electric circuit?

(Cell; connecting wires; power lines; bar magnet).

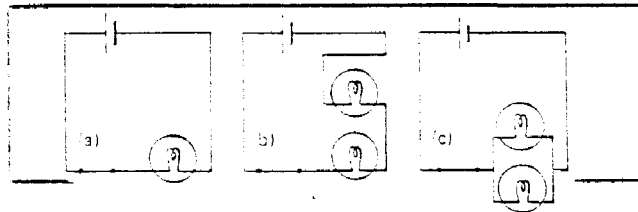
2.5). Which of the following will conduct an electric current?

(Wood; glass; copper).

[2]

Question 3

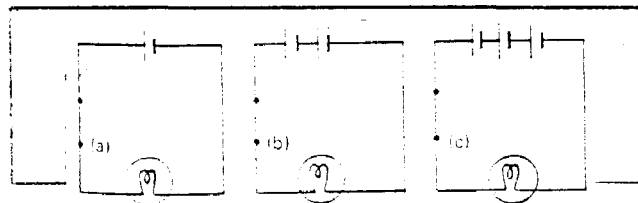
Which of the following circuits are series circuits?



[1]

Question 4

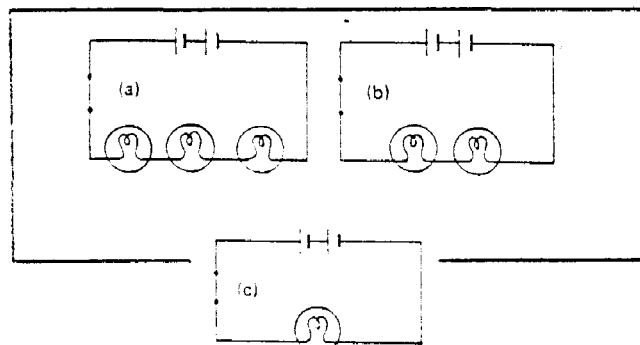
In which one of these circuits will the bulb glow the brightest?



[1]

Question 5

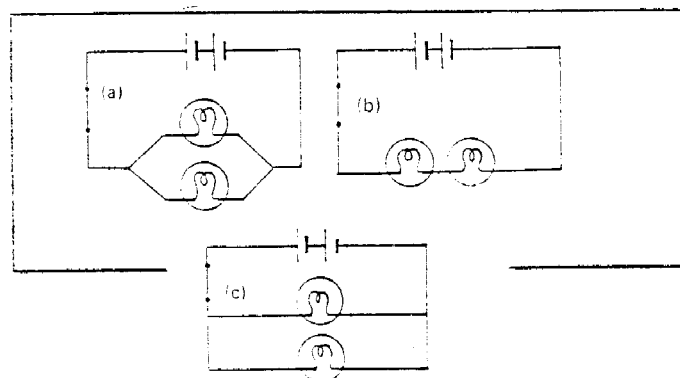
In which of these circuits will the resistance be greatest?



[1]

Question 6

In which of the following circuits are the light bulbs connected in **parallel**?



[1]

Question 7

What do we call a material which will carry an electric current?

[1]

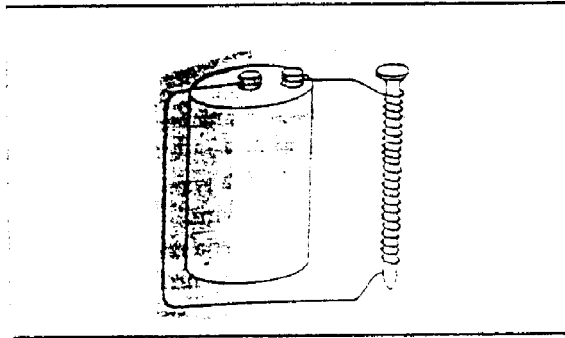
Question 8

Complete the sentences by writing down words in the empty spaces:

- (a). In household appliances like electric stoves and kettles _____ energy is transformed into _____ energy. [2]
- (b). A _____ is put into a circuit to prevent damage in the case of a short circuit. [1]
- (c). When an electric current is passed through a solution a reaction takes place and _____ energy is transformed into _____ energy. [2]
- (d). When an electric current is passed through a copper chloride solution the substances which are formed are _____ and _____. [2]

Question 1

Have a look at the sketch. Say what you think will happen to the nail?



[20]

Bonus Question

Read the following passage and answer the questions which follow:

Temba asks the question: "Would electrons move when a magnet passes through a coil of wire?"

This puzzled a scientist several hundred years ago, and he decided to experiment. His experiment worked, and that marked the beginning of many wonderful things.

If we use a small magnet and a small wire, only a few electrons would move. But when we move very powerful magnets inside thousands of coils, many electrons flow. It doesn't matter whether the magnets or the coils move, but it's the movement which generates the electricity.

Question

In a sentence, write down what the passage is talking about.

[5]

APPENDIX J

Comprehension test and learner contributions

Comprehension Test

Read the following passage and then answer the questions which follow:

WHO DISCOVERED ELECTRICITY?

The curious thing about electricity is that it has been studied for thousands of years - and we still don't know exactly what it is! Today, all matter is thought to consist of tiny charged particles. Electricity, according to this theory, is simply a moving stream of electrons in metals.

The word "electricity" comes from the Greek word *electron*. And do you know what this word meant? It was the Greek word for "amber"! You see, as far back as 600 B.C. the Greeks knew that when amber was rubbed, it became capable of attracting to it light bits of cork or paper.

Not much progress was made in the study of electricity until 1672. In that year, a man called Otto von Guericke produced a more powerful charge of electricity by holding his hand against a ball of spinning sulphur. In 1729, Stephen Gray found that some substances, such as metals, carried electricity from one location to another. These came to be called "conductors". He found that others, such as glass, sulphur, amber, and wax, did not carry electricity. These were called "insulators".

The next important step took place in 1733 when a Frenchman called du Fay discovered positive and negative charges of electricity, although he thought those were two different kinds of electricity.

But it was Benjamin Franklin who tried to give an explanation of what electricity was. His idea was that all substances in nature contain "electrical fluid". Friction between certain substances removed some of this "fluid" from one and placed an extra amount in the other. Today, we would say that this "fluid" is composed of electrons which are negatively charged.

Probably the most important developments in the science of electricity started with the invention of the first battery in 1800 by Alessandro Volta. This battery gave the world its first continuous, reliable source of electric current, and led to all the important discoveries of the use of electricity.

Questions

- (1). What is electricity considered to be according to the latest theory?
- (2). *Electron* is a Greek word. What does it mean in English?
- (3). Who produced a more powerful charge of electricity by holding his hand against a ball of spinning sulphur?
- (4). What did Stephen Gray discover in 1729?
- (5). Who discovered the existence of positive and negative charges of electricity and in what year?
- (6). Benjamin Franklin tried to explain electricity in terms of “fluid” which was transferred from one substance to another when they were rubbed together. According to this passage what is this “fluid”?
- (7). Who discovered the battery?
- (8). Give the meaning of each of the following words which appear in the extract:

stream, bits, conductors, different, substance, composed, invention.

Total [15].

Veronica Escal
Grade 8J

30 $\frac{3}{10}$

w.eyw
98,05-06
01/05/08

Electricity according to this theory, is simply a moving stream of electrons ~

It's from electricity

30th Jan 1752 Benjamin Franklin produced a more powerful

in 1729 Stephen Gray found that some substances such as plastic
carried electricity from one location to another

in 1733 when a French man called du Roy discovered positive and negative charges of electricity, although he thought there were two different kinds of electricity

Benjamin Franklin who tried to give explanation of what

?

8

10⁰
Questione Lihembiso



2. 4. 06
98.05.06
Question

7 May 1998

1. The curious things about electricity is has been studied for thousands
2. It comes from Greek word electron
3. He discover grounds that other, such as glass, sulphur, Amber and wax,
4. such as glass, sulphur, Amber, wax
5. in 1733
6. A fluid is a electricity fluid
7. A fluid is a electricity fluid
8. Substance

209
Makaza Theminkas

2
10

w l.w
98-05-06

6 May 1998

Grade 8 G

Comprehension Test

1) Electricity according to this theory is simply a moving stream of electrons in metals.

2. ~~5th~~

3. Otto von Guericke

4. substances such as metals.

5. The curious thing about electricity is that it has been studied for thousands of years.

6.

7. Electricity X

8.

Cerna Vuyiseke

Grade 89

2
10

24.12.06. 207
98-06 Mar 1893

1

X

2 The word 'electricity' comes from the Greek word electron
3 produce a more powerful charge of electricity by holding his
hand against a ball of spinning sulphur

4 In 1722, Stephen Gray, found that some substances, such as
metals, carried electricity from one location to another

5 the next important step took place in 1733 a Frenchman called
du Fay discovered positive and negative charges of electricity

6 Although he thought there were two different kinds of electricity

7 But it was Benjamin Franklin who tried to give an
explanation of what electricity was. His idea was that all sub-
stances in nature contain 'electricity fluid'

8 Discoveries of the use of electricity

X

Kholiswa Nlesani
GRADE 89

3/10
Comprehension Test

m. l. w
98.105.06

309
06.05.08

1. For thousands of years and we still don't know exactly what it is.
2. STEPHEN GRAY YES. It means a conductor.
3. STEPHEN GRAY is the producer of spinning sulphur.
4. He discovered the spinning sulphur.
5. FRENCHMAN who called it Fay.
6. YES. Fluid is composed of electrons which are negatively charged.
7. Alessandro Volta is the discoverer of the battery.
8. stream - to be afraid
- bits - to wit someone
- conductors - battery
- different - difficult thing or word
- substance - circuit
- composed - electrons
- invention - first battery in 1800 by Alessandro Volta

Dylan McConnaughey

309 (3/10) TEST

w.l.g.w
98-05-06

06/05/13

1. Electricity according to this theory is simply a moving stream of electrons in metals
2. It was the Greek word for amber. You see us far back as 600 B.C
3. Otto von Guericke produced a more powerful charge of electricity by holding his hand against a Ball of spinning sulphur.
4. In 1729 Stephen Gray found that some substances conductors
5. Benjamin Franklin gave the first explanation of an electric charge.
6. Discovered positive and negative charge of electrons.
7. ~~Discovery of the use of electricity.~~
8. Stream - electricity X
9. Bits - Cork or paper X
10. Conductors - X

Physics Test.

509

Questions.

1. All matter is thought to consist of ~~only~~ tiny charged particles. Electricity, according to this theory is simply a moving ~~stream~~ of electrons in metals.
2. It means electricity in English. X
3. Was Otto von Guericke.
4. Stephen Gray discovered in 1729 some substances such as metals, carried electricity from one location to another.
5. Faraday called out by discovered positive and negative charges of electricity in 1733.
6. His idea was that all substance in nature contain "electrical fluid". fluid is ~~from one~~ and placed an extra amount in the other.
7. Was discovered by Alessandro Volta.
- 8.

1. Stream
2. bits
3. conductors
4. different
5. substance
6. Composed
7. Invention.

Phibbsville Thomas ^{HC} ^{W 9/12} 4
105 98-05-06
6 May 1993

Grade 8

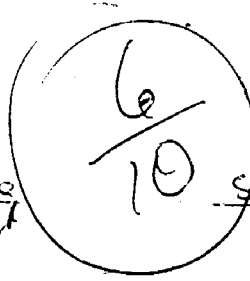
Question 1

- (1) Electricity, according to this theory, is simply a moving stream of electrons in metals.
- (2) The word "electricity" comes from the Greek word *electron*.
- (3) In that year a man called Otto von Guericke produced a more powerful charge of ~~electricity~~ electricity by holding his hand against a ball of spinning sulphur.
- (4) In 1729, Stephen Gray found that some substances, such as metal, carried electricity from one location to another.
- (5) ~~But~~ Ben Franklin discovered positive and negative charges.
- (6) X
- (7) By Alessandro Volta ✓
- (8) substance X

Maheta

Atombatteries

609



Std six

n. e. w

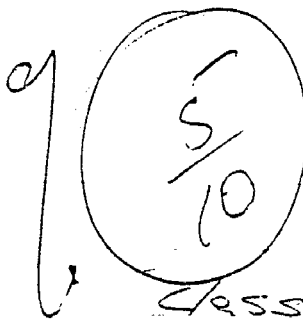
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06. 05. 98

P. science Test

1. Electricity, according to this theory, is simply a moving stream of electrons in metals.
 2. It was the Greek word for "amber"! You see,
 3. Otto von Guericke
 4. Substances, such as metals, carried electricity ~~from~~ one location to another
 5. 1733
 6. His idea was that all is "electrical fluid"
 7. A 1800 by Alessandro Volta
 8. Composed - electrons X
 - Substances - metals X
 - Conductors - X
 - different - between X
 - bits - cork or paper X X
 - stream - electrons in metals
 - invention - X
-

NGANDI 50
GRADE 89



w. g. w.
98-05-06

6/05/1982

question

Class TEST

- 1 is simply a moving stream of electrons in metals ✓
- 2 Electricity ✗
- 3 OTTO VON GUERICKE ✓
- 4 1729 STEPHEN GRAY found that same substance such as metals carries electricity from one location to another ✓
- 5 In 1733 a Frenchman called du FAY discovered negative and positive ✓
- 6 friction between certain removed of this fluid ✗
- 7 Alessandro VOLTA ✓
- 8 stream the face of a thing eg white stream something is not the same like others ✗

APPENDIX K

Learner Contributions to Worksheet Assignments

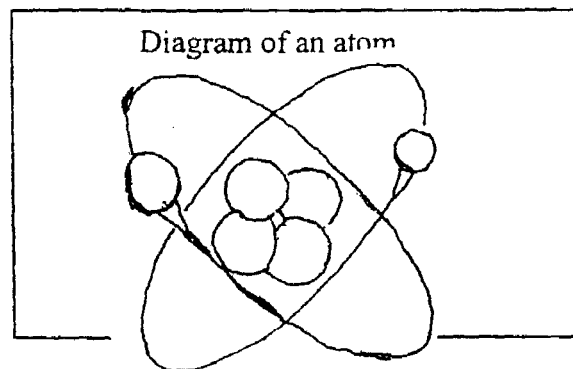
Electricity - Magic at your finger tips

Just think how you used electricity today. Were you awakened by an electric alarm clock? Did your father shave with an electric razor? Did your mother make toast with an electric toaster?

Did you watch television before going to school? Did you ever stop to wonder what makes your doorbell and telephone work?

Think of all the things in the world that electricity makes work, and you will see why anyone might use the word "magic" for it.

Scientists have a theory about the nature of electricity. Before we can understand electricity, however, we must first discuss the make-up of materials such as electric wires. These wires are made up of atoms which are further made up of smaller particles called electrons, protons, neutrons, and many others.



Scientists believe that electricity is made up of electrons that are part of all material. When we get these electrons to move, we have an electric current - electricity.

So what makes these electrons move?

The answer is a power source such as generators or simple torch cells. The electricity - or moving electrons - is pushed through wires and makes bulbs glow, for example.

Task

- (1). Name 5 pieces of equipment which use electricity.
- (2). Explain in your own words why a bulb glows when connected in an electric circuit.

(1) T.V, stove, alarm, geyser, electric blanket

(2) because when you connected a bulb in a electric circuit the will be cells that are going to provide electrical energy and that make the bulb to glow.

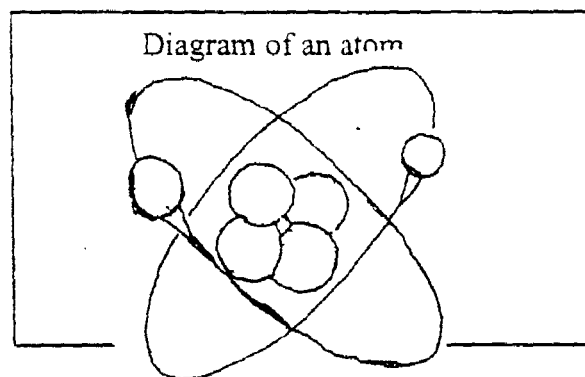
Electricity - Magic at your finger tips

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Did you watch television before going to school? Did you ever stop to wonder what makes your doorbell and telephone work?

Think of all the things in the world that electricity makes work, and you will see why anyone might use the word "magic" for it.

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Scientists believe that electricity is made up of electrons that are part of all material. When we get these electrons to move, we have an electric current - electricity.

So what makes these electrons move?

The answer is a power source such as generators or simple torch cells. The electricity - or moving electrons - is pushed through wires and makes bulbs glow, for example.

Task

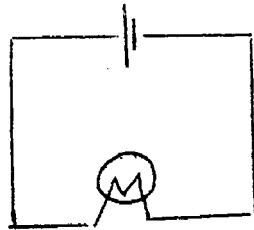
- (1). Name 5 pieces of equipment which use electricity. 1. Stove 2. T.V. 3. Radio 4. Hair dryer 5. Torch
- (2). Explain in your own words why a bulb glows when connected in an electric circuit.

- complete -

Task:

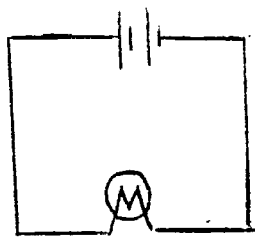
Connect up the following circuits and answer the questions which follow

Circuit 1:



What happens to the globe?

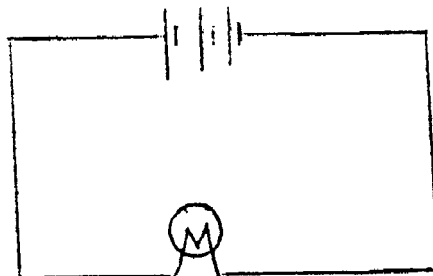
Circuit 2:



complete

Compare to circuit 1 and explain what happens to the globe?

Circuit 3:



Compare to circuit 2 and explain what happens to the globe?

Conclusion:

It is brighter not so long because of one cell (wrong)
but I know what you mean

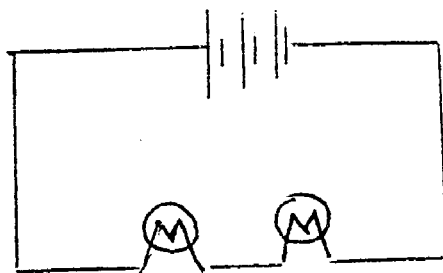
Now explain what makes the globe shine in each case?

Circuits in series and parallel

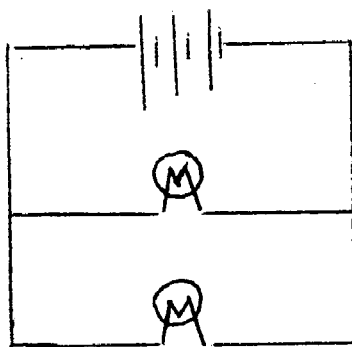
Task:

Connect up the following circuits and answer the questions which follow:

Circuit 1:



Circuit 2:



Questions

- (1). What do we call circuit 1 and circuit 2?

SERIES CIRCUIT

- (2). In which circuit are the lamps brighter?

CIRCUIT 2

- (3). Explain why you think this should be so?

because of THREE cells
and it is PARALLEL CIRCUIT THE
SECOND ONE

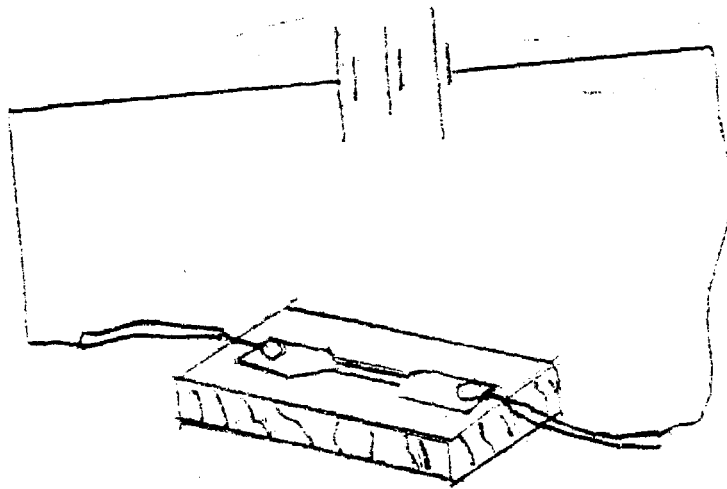
be brighter NO FOR THE SECOND ONE

because of TWO cells

Again...

The fuse - "The policeman of electric circuits"

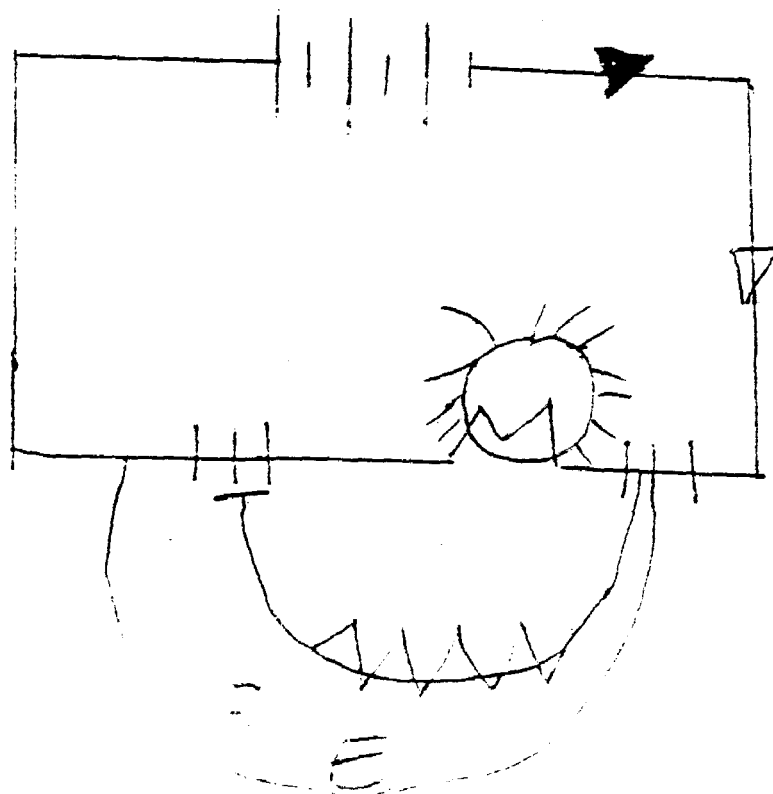
With a thin sheet of tin foil connect up the following circuit:



After a short time, what do you notice?

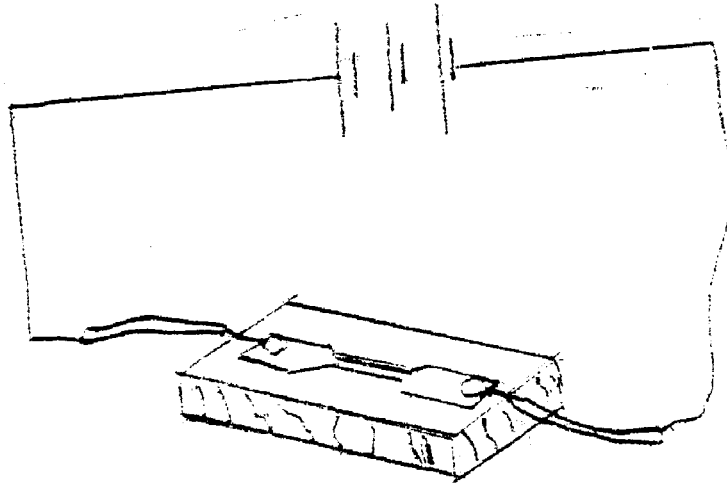
It lights dim. ELECTRICAL current.

Can you explain it?



The fuse - "The policeman of electric circuits"

With a thin sheet of tin foil connect up the following circuit:



After a short time, what do you notice?

I notice that the fuse help the electric current to work.

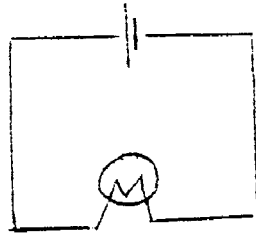
Can you explain it?

If you put a fuse and you connect it in the -
circuit the glass will shine

Task:

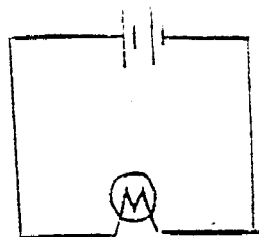
Connect up the following circuits and answer the questions which follow

Circuit 1:



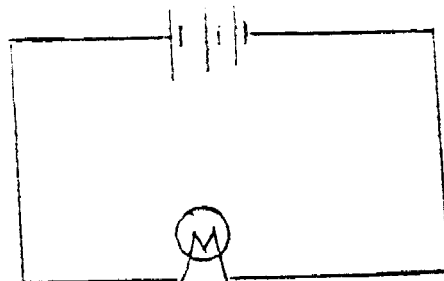
What happens to the globe? *its light/shines*

Circuit 2:



Compare to circuit 1 and explain what happens to the globe? *its bright because ~~both~~ have 2 cells and it gets power from that cells*

Circuit 3:



Compare to circuit 2 and explain what happens to the globe?

Conclusion:

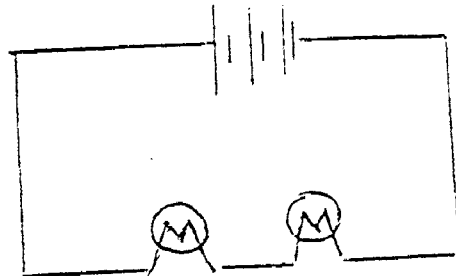
Complete

Circuits in series and parallel

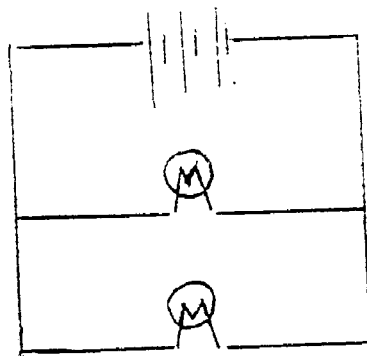
Task:

Connect up the following circuits and answer the questions which follow:

Circuit 1:



Circuit 2:



Questions

- (1). What do we call circuit 1 and circuit 2? *The bulb is light in*
- (2). In which circuit are the lamps brighter? *The circuit bulb light*
where. Bright
- (3). Explain why you think this should be so?

APPENDIX L

Adapted Journal Articles and Accompanying Assignment

Assignment: Class presentations

You have been given *Time* magazine articles and in your groups you will be expected to do the following:

- (1). Read the article and decide what it is talking about.
- (2). Decide what is the central idea being talked about in the article.
- (3). Prepare a 5 minute presentation where you will, **as a group**, team teach the concept to the rest of the class. In your lesson you must explain how the idea spoken of in the article effects the everyday-lives of people.
- (4). In your presentation you must make use of visual- aid material such as cardboard charts, overhead transparencies, reference books or even models which you may have made.

Let me warn you... This is not a play exercise for it needs careful planning and hard work to organise your presentations.

You will be marked as follows:

Task Marked	Mark
Ability to see central concept of article	10
Use of displays, charts, models	10
Presentation itself	10
Ability to show breakdown of work done by each member of the group	10
Class mark given to group for their presentation	10

Total: [50]

World's rice crop vulnerable to changing atmosphere

RICE, the world's most important food crop, will be especially hard hit by man-made changes to the atmosphere, according to a biologist in the US. Although most plants will grow better as we add more carbon dioxide to the air, these benefits will be more than cancelled out by increased ultraviolet light from the Sun, penetrating a depleted ozone layer.

Alan Teramura at the University of Maryland has carried out the first experiments in which the levels of both carbon dioxide and ultraviolet light are raised to those expected by the mid-21st century. He has studied the effect on a number of crops, most notably rice and wheat.

In earlier work, Teramura grew soy beans and tobacco plants under sunlamps which generate so-called UV-B light (with a wavelength between 280 and 320 nanometres). He found that a one per cent depletion in the ozone layer would lower the yield of soy beans by one per cent. He also found that his tobacco suffered small but cumulative losses in their total biomass. *New Scientist*, Science, 1 October (1990).

In his latest experiments, Teramura exposed plants to normal sunlight, while nearly doubling the concentration of carbon dioxide, from 355 to 650 microlitres per litre of air. He raised the intensity of UV-B to the level expected if the ozone layer at the equator were thinned by 10 per cent. In "comparison" plots, Teramura increased either carbon dioxide or UV-B alone.

Teramura found that when rice was exposed simply to more carbon dioxide, the yield of its seed and its biomass increased by 20 per cent. Wheat did even better, increasing its biomass by up to 50 per cent. "But when I raised UV-B as well as carbon dioxide," says Teramura, "the increase seed

Christopher Joyce, Washington DC

yield in both was wiped out." He also found that the biomass of rice did not seem to increase at all.

"We are intrigued with rice because half the people in the world get 70 per cent of their calories from rice," says Teramura. Ironically, however, rice paddies emit significant quantities of methane, a gas



Crop of worries: rice will benefit from more carbon dioxide, but the benefit will be more than wiped out by increased ultraviolet

which contributes to global warming and which also depletes ozone.

Teramura's results are not without some contradictions, however. When he tested soy beans in a similar way to the rice, he found that they actually gained in seed yield and biomass when he increased the level of carbon dioxide and UV-B. Also, Teramura found that when he exposed rice to increased levels of UV-B, without raising the level of carbon dioxide, it had no apparent effect on growth.

Teramura says that different species of plant vary widely in how sensitive they are not only to changes in ultraviolet light but to

changes in the ratio of UV-B to visible light. He says it is possible that UV-B may interfere with the process of photosynthesis, making plants unable to respond to enriched carbon dioxide.

Although Teramura has found no clear link between a plant's physiology and its sensitivity, he suggests that geography—specifically, the place where a plant evolved—may count the most. Plants in lower, equatorial latitudes have been receiving 50 per cent more UV-B at midday than plants in higher, temperate latitudes, and they have been receiving this for at least a million years. The reason is that the ozone layer is thinner around the planet's midsection: rays have a shorter path and are less attenuated.

As a consequence of this, says Teramura, plants from temperate zones have not evolved mechanisms for protecting themselves from UV-B. He and his colleague, Martyn Caldwell of Utah State University, estimate that more than half the crops that originated in the Near East, Northern China and Mesoamerica are sensitive to UV-B. On the other hand, only 5 per cent of those from Africa, Southeast Asia and South America are classified as sensitive.

Global warming can also harm plants by making them too hot. Teramura reviewed the literature on crops and temperature and found that temperatures near 40 °C can seriously stunt the growth of cereals, such as rice, wheat and corn. According to researchers at the Goddard Institute of Space Studies, a doubling of carbon dioxide would raise summer temperatures by almost 5 °C, enough to cripple or extinguish rice crops. Such a doubling of concentration could occur by the middle of the 21st century.

Will wayward asteroid become a moon of Jupiter?

AN ASTRONOMER in the US has discovered an asteroid that crosses the orbit of the planet Jupiter. Such asteroids are members of a rare class and may hold clues to the nature and origin of some of Jupiter's family of 16 satellites.

Carolyn Shoemaker at Palomar Observatory in California discovered the new "Jupiter-crosser", designated 1990 UL₁, in early November last year. Shoemaker was examining photographs she and her colleague, David Levy, had taken with the observatory's 46-centimetre telescope on 25 October. The asteroid was moving south along the border between the constellations of Pisces and Aries.

Very few asteroids cross the orbit of Jupiter, even though many bodies are known to orbit outside the main asteroid belt, which lies between the orbits of Mars and Jupiter. The most famous Jupiter-crosser is Hilda, which was discovered in 1920. Hilda travels from the asteroid belt out

as far as the orbit of the planet Saturn.

Gareth Williams of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, analysed the new asteroid's observed positions, and computed its path. He found that 1990 UL₁ follows an elongated orbit. When it is closest to the Sun, it is between the orbits of Mars and Jupiter, but when it is at its farthest, the body travels between the orbits of Jupiter and Saturn. The asteroid is small, with a diameter of only a few kilometres.

Williams has calculated that 1990 UL₁ orbits the Sun every 9.3 years. During this time, its distance from the Sun varies from 1.8 to 7.0 astronomical units: 1 astronomical unit (au) is the average distance between the Sun and the Earth. For comparison, Mars is 1.5 au from the Sun, Jupiter 5.2 au, and Saturn 9.5 au.

Astronomers have catalogued more than 100 asteroids that lie in Jupiter's orbit—the so-called Trojan asteroids—but they have

found very few that actually cross Jupiter's orbit. Because the Trojan asteroids circle the Sun 60° ahead of or behind Jupiter, they are always far from Jupiter.

Jupiter-crossing asteroids are interesting because they may one day collide with Jupiter or its moons. Indeed, astronomers believe that some of the craters on Jupiter's moons were created when Jupiter-crossing asteroids or Jupiter-crossing comets smashed into the satellites.

But Jupiter-crossing asteroids are interesting for another reason. Jupiter's gravity is so strong that the planet may actually capture passing asteroids and make moons of them. In fact, Jupiter's four outermost moons are probably captured asteroids or comets. These moons orbit Jupiter in the opposite direction to the other 12 moons, which strongly suggests that they did not form with the other Jovian satellites. Some say the asteroid 1990 UL₁ may itself become a moon of Jupiter.

Ken Crosswell, Boston

World's rice crop vulnerable to changing atmosphere

New Scientist, 12 January 1991

By Christopher Joyce

Rice, the world's most important food crop, will suffer because of man-made changes to the atmosphere, according to a biologist in America. Although most plants will grow better as we add more carbon dioxide to the air, there will be increased ultraviolet radiation from the Sun to destroy the weak rice crops.

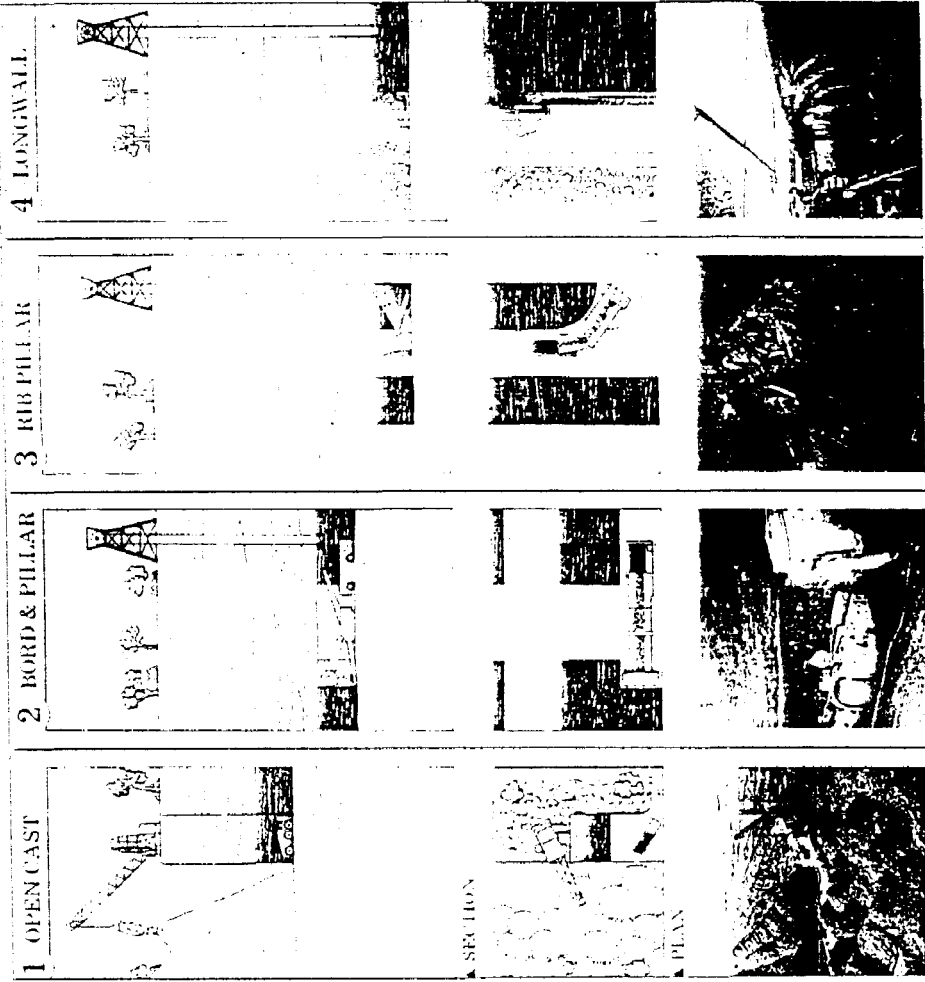
Alan Teramura at Maryland University has done experiments where rice plants were grown in greenhouses with the same carbon dioxide and ultraviolet light levels expected in the mid-21st century. In these experiments he shone ordinary sunlight onto the rice plants while doubling the normal amount of carbon dioxide in the greenhouse. He then raised the intensity of the sunlight and noted their effects on the rice plants.

Teramura found that when carbon dioxide levels increased, the yield of its seed and plant mass increased by 20%. But when he raised the ultraviolet levels as well as the carbon dioxide levels the seed production and crop yield were entirely wiped out.

The big problem with Teramura's study is that half of the world's people get 70% of their energy from rice and that in 50 years time with such vast amounts of carbon dioxide in the air and intense ultraviolet radiation there will not be enough food for all.

Teramura carries on with the idea that plants are very sensitive because of their geographical location. Ultraviolet rays are very intense around the earth's equator and so plants in that area have had to deal with severe sunlight. Rice, however, is more sensitive because it is a plant which has been grown for thousands of years in the cooler, more northerly parts of the world. Thus, with a sudden increase in ultraviolet light and carbon dioxide expected in the middle of the 21st century it spells *disaster*.

Other researchers have found that by the middle of the 21st century the carbon dioxide levels in the air would have more than doubled and as a result of global warming would have raised the temperature by 5 C, enough to destroy the rice crop. This is sad news for the world's people who can expect serious food shortages.



COAL

The mineral for all seasons: Part 2



G. C. VICARIUS and D. H. HODGKIN, *Information Center on the Chemical Industry and School of Process and Materials Engineering, University of the Witwatersrand*

Coal mining

Coal deposits are spread out over much of the eastern part of South Africa (Fig. 1). Depending on the nature of the deposit two main methods of mining are used. These are called underground and opencast. By *underground* mining is meant the driving of tunnels (known as *workings*) into the opencast mining, soil and other material on top of the seams are known as 'overburden' are removed, and then the seams taken out. The overburden is then replaced. The decision whether to use one method or the other is essentially a matter of the thickness of seam or seams, and the depth at which they occur. If they are less than 50 metres deep, and the ratio of overburden thickness to seam thickness is about 7 or less, opencast mining is probably cheaper than underground mining. Opencast mining has the advantage that some 90% of the coal seam is recovered. When underground mining is employed, depending upon the method, the seam recovery may be 50% or less, though with certain methods up to 60% recovery is possible.

Fig. 2: Mechanized coal wheel (top of page 34) page 34
Fig. 3: Coal mining methods (opposite page)

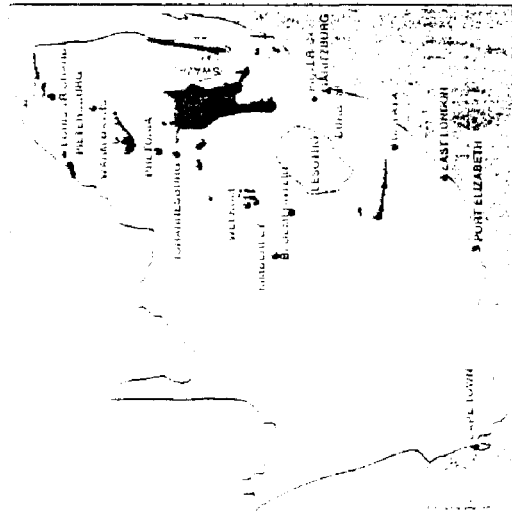


Fig. 1 Coal deposits in South Africa

Opencast mining

In its simplest form, the overburden is removed at a point where the seam reaches the surface (outcrop). Otherwise, a long ditch is dug, known as a box cut. Once the seams have been reached, large earth moving devices, known as drag lines, progressively remove the top soil, then the overburden, down to the seams. When the seams are exposed, trucks in the pit bottom are loaded with the coal, using mechanical shovels. Both the overburden and the seam usually require to be broken with explosives. When the seam has been taken out, the dragline removes more overburden from the side of the pit. As the pit progresses the overburden is dumped into the pit bottom. At a still later stage, the top soil is replaced, and agriculture recommenced. It is argued that properly reasoned land can actually have its agricultural properties improved, as drainage is facilitated.

Underground mining

There are basically two methods of underground mining — 'bord and pillar' and 'longwall'. In 'bord and pillar' or 'room and pillar' working, the coal is removed by driving a series of roughly square rooms into the seam. The ground is supported by pillars left between the rooms. In the earlier form, the coal was mined out by hand, the coal being loaded into small tubs, which were then transported to the mine surface. Although a number of mines still operate in this way, coal mines using bord and pillar methods are usually highly mechanized. The seam first has a cut made along the bottom by a coal cutter consisting of a series of picks mounted on a chain. This, like some vast electric cutting knife, cuts into the seam. Holes are drilled in the seam above the cut, and the coal blasted out. Mechanical shovels or loaders then move in, loading the coal into self-discharging trucks known as shuttle cars. These shuttle backwards and forwards between the mining place and the conveyor belt taking coal out of the mine.

In longwall working, the coal seam is exposed along a length up to 200 metres, known as the 'face'. Coal cutting machinery moves along the face, the seam is then blasted down and loaded onto a conveyor belt moving along the length of the face. After a 'cut' of the seam has been taken, the belt is moved towards the face and the sequence is repeated. Generally the ground collapses after the seam has been removed, props keeping it in position until the mining cycle has advanced sufficiently for collapse to be allowed. Other loaders are also employed by means of which the coal is loaded onto the belt as it is cut from the face.

In South Africa, bord and pillar is still the most popular method of underground mining and most coal is still won by underground methods. Opencast mining, from being virtually unused in the early nineteen seventies was, by 1988, responsible for about 35% of the coal produced. The use of opencast methods is tending to increase.

Coal qualities

The coal qualities produced in South Africa are shown in Table 3 (see Part 1). The table shows that apart from the coal used in thermal power stations and for oil-from-coal processing, the qualities used differ widely from the qualities available in the reserves defined as Table 2 (see Part 1), using calorific value as the quality criterion. Poor quality run-of-mine coal is upgraded to meet consumer standards in coal-preparation plants, in which the coal is, quite literally, washed.

Coal preparation

Coal, as mined, cannot be used by the consumer in most instances. It must be graded into size ranges suitable for the consumer and may have to have some of the mineral matter removed from it.

Sizing and crushing

Coal from the mine ('run-of-mine') passes over screens. These are large moving sieves, which sort the coal into different sizes. Coal too large for treatment (say over 100 mm) is crushed or broken down, e.g. by passing between crushing rolls. These are cylinders, bearing tough metal teeth, which rotate and draw the coal between them, breaking the lumps as they pass through.

To remove unwanted mineral matter, coal is washed. In the washing process, coal particles with little mineral matter (high grade) are separated from the particles with an unacceptable level of mineral matter, as well as from pure stone. Sometimes the run-of-mine coal is separated into three different categories: a high calorific value product (say of 29–30 MJ kg⁻¹) a medium calorific value fraction (say of 27–28 MJ kg⁻¹) and a low-grade fraction, generally, or less than 15 MJ kg⁻¹. The last grade is usually rejected. South African coal is of such a composition that in order to make high-calorific value coals suitable for export, quite a lot of low-grade but still combustible discard must be produced. However, pending the developments of markets for such a grade of coal, (e.g. power generation at the mine), the discards are preferably stored so that they will not catch fire spontaneously, and so are conserved for future usage.

Coal washers are of several different kinds. The simplest rely upon subjecting the coal to alternate upward and downward currents of water (jigs). The action causes the particles to become sorted into zones, with the highest-calorific value particles at the top, the lowest at the bottom. The zones may then be separated. In South Africa the dense-medium process is more commonly employed. In this process a suspension of finely ground iron oxide (magnetite) and water is used. The proportion of iron oxide may be controlled so that the density of the suspension will just permit the desired grade of coal to float on the surface, from which it is removed. By following a first stage with a second stage, operating at a different density, the coal may be split into several different qualities.

All South African coal goes through some sort of preparation. If good-quality seams are being mined, preparation may simply entail screening the coal into different sizes. If coals are required with a carefully controlled calorific value or ash content, they must be washed. About 40% of South African coal is washed. ESKOM, the biggest single user of coal, generally burns unwashed coal after it has been crushed to pass through a 20 mm screen. The massive boilers may be designed to burn low-calorific value coals, so that washing the coal for such uses is, in the majority of cases, unnecessary.

Coal is a complex hydrocarbon substance, which readily reacts with oxygen in an exothermic reaction. The main use of coal is as a fuel. In thermal power stations (the biggest single usage of coal on a worldwide basis), coal is burned to give thermal energy which is used to boil water to give steam which in turn makes turbines rotate to generate electricity. Coal is also used on a relatively small industrial scale, mainly in automatically stoked boilers, to generate steam. In several countries, quantities of coal are still supplied as a domestic fuel to be burned on hearths and in stoves of varying kinds. Some coal is still used to fire steam locomotives; although, in most parts of the world, locomotives are powered by diesel fuel or electricity.

The carbon in coal, may also have a chemical use. It may act as a reductant in the metallurgical industry, in which carbon, reacting with metallic ores, liberates the metal itself. In the steel industry, coal is usually converted into coke, which is the reductant employed in blast furnaces. However, the 'direct-reduction process' is also used. In this process, the ore is mixed with coal, the thermal energy from the burning volatile matter from the coal providing the heat that enables the reduction process to take place.

Coal may also be converted into gas. When coal is heated to make coke, gas and tars are evolved. The method, known as 'carbonization', was the first by which gas was made from coal. The preferred method of manufacturing gas from coal (as used on the large scale at, for example, the SASOL plants) is to pass a mixture of steam and oxygen through the coal. There are many proprietary processes in which this operation may be carried out. Typical of these is the Lurgi process, in which the coal is in lump form; the Winkler process, in which coal less than about 3 mm in size is gasified in a fluidized bed (a bed of fine particles, kept in motion by the passage of gas through the bed and which behave very much like a liquid); and the Koppers Totzek process in which coal, powdered to less than 1 mm in size is blown or carried along in a stream of reacting gases.

The gas from coal is used for various purposes, either combining the different gases ('synthesis') to give liquid fuels, as carried out at SASOL; as a heating gas for domestic and industrial use; and as feedstocks to make chemicals, e.g. methyl alcohol. The process of converting coal into gas and then into liquid fuels is known as 'indirect liquefaction'. It is currently the only process for making liquid fuels from coal that is employed commercially and on a large scale. Coal may also be converted directly into liquid fuels. The major difference between coal and liquid fuels is the amount of hydrogen combined with the carbon. Processes have been devised, and have been used commercially, in which hydrogen is caused to combine with coal, the product being liquids that may be refined to give petroleum substitutes. These

processes are costly, and at the present stage there are no commercial hydrogenation installations. Coal is also used as a chemical feedstock; for example it can be reacted with limestone to give calcium carbide. The addition of water to calcium carbide generates acetylene.

Pollution control

The combustion of coal can give rise to several kinds of pollution, visible and invisible. Smoke emission which is caused by incomplete combustion is controlled by legislation. Industrial appliances, in general, now allow complete combustion to take place. Particles of ash may also be emitted from a coal burning device, e.g. from a power-station boiler. The emission of dust may be prevented by the use of filters or electrostatic precipitators, the latter being devices which cause the particles to become charged and hence be precipitated from the gas stream in which they are being carried along. The invisible pollutants, giving rise to the so-called acid-rain phenomenon are causing concern. They are of two main kinds:

- Oxides of nitrogen caused by the combination of nitrogen in the coal with oxygen
- Oxides of sulphur, caused by the combustion of sulphur-bearing constituents of coal, such as iron pyrites.

The two pollutants are known popularly as 'NOX and SOX'. The technology to control both kinds of pollution is available, but costly. The current preference to reduce their formation is to use coals low in both sulphur and nitrogen constituents. Reduced 'NOX' production results from lowering combustion temperatures, and the development of fluidized-bed combustion systems may result in lower emission rates. 'SOX' emission can be controlled, in many instances, by washing the coal, as the iron pyrite is of high density and can be removed easily by washing. In other coals, however, the sulphur is differently 'bound' in the coal and is relatively unaffected by washing. In such instances, the gas formed during combustion ('flue gases') may be scrubbed. In the USA, for example, power stations are tending to be equipped with flue gas desulphurization equipment.

From the time that intense industrial development commenced in the northern hemisphere, say from the early eighteenth century, coal was pre-eminently the energy source employed. The uses of coal enumerated above were all fully developed by the first part of the twentieth century. For example, during World War II, most of the liquid fuel used in Germany was made from coal. However, from the mid-nineteen fifties, as the oil industries developed, particularly those based on Middle East sources, the usage of coal went into a sharp decline. Since the 'oil crisis' which started in 1973, the use of coal has shown a tendency to increase, in applications where it had been largely supplanted by oil. This trend may continue, though the fluctuations in energy demand and energy prices makes the prediction of trends in any one energy source somewhat imprecise.

Coal usage in South Africa

South Africa, possessing only one indigenous fossil fuel, coal, in fairly abundant supply, is almost uniquely dependent upon coal as a source of energy. It is estimated that 75% of the nation's energy needs are provided by coal. The balance is largely imported oil, with some hydro and nuclear power making up the total.

Coal is used in the following sectors.

Electricity generation

This is the major coal-consumption sector. 37% of all coal sold in 1986 was used for power generation. About 91% of all power generated comes from stations operated by ESKOM, the balance being from municipalities and a few privately operated generating facilities. ESKOM power stations sent out 127 billion kWh in 1986, and burned 67 m tons of coal to produce it. The average thermal efficiency of power stations in 1986 was 32.9%, a figure which has been steadily increasing as more and more electricity is produced in large, efficient units. 95% of ESKOM power was generated in power stations located at the pit (compared with 80% in 1977), as this location virtually eliminates transport costs. The coal used in power generation tends to be of medium quality; one power station in the Free State is designed to burn very low-quality coal (about 16 MJ kg⁻¹ at New Vaal Colliery, supplying Lethabo Station).

Virtually all the coal used in electricity generation is unwashed. New Vaal Colliery has a washing plant designed to remove large pieces of stone. Prior to 1970 all coal for ESKOM was coal from underground mines. Opencast mining is increasingly used and by 1986, about 35% of ESKOM's coal came from open pits.

The growth in electricity production was steady at about 8–10% per annum prior to 1981. However in 1982 and 1983, the growth was only 2–3%. If a 5% growth is maintained to the year 2000, consumption of coal could reach about 130 million tons per annum by that date.

Metallurgical coal

The metallurgical industry consumed some 8.5 million tons per annum in 1986. Most coal was used by ISCOR. ISCOR's main use of coal is to convert it into coke and then use that material in the blast furnace. About half of ISCOR's coal comes from their own sources, the remainder is purchased from mining companies.

The coal used in the metallurgical industry must be washed to maintain high and consistent quality. South Africa has only limited reserves of coking coal; employing processes that do not require coking coal (such as the direct-reduction process) diminishes the need to extend mines in environmentally sensitive areas, such as the Kruger National Park.

The major ISCOR mine in the Waterberg (Grooteegeluk) employs opencast methods to produce about 1.8 million tons per annum; the remainder of the metallurgical coal comes from underground mines.

Oil from coal

South Africa, uniquely in the world, produces considerable quantities of liquid fuels from coal. The first SASOL plant, built at Sasolburg in the Free State, started in the 1950s. SASOL I, the original oil-from-coal plant, has over the past few years been converted from a mainly fuel-producing plant to one which is dedicated to the production of a wide range of chemical feedstocks. SASOL II and SASOL III each process about 10 million tons of coal per annum to give 1.7 million tons per annum of liquid products.

The processes are based on the Fischer-Tropsch synthesis reaction, in which a mixture of carbon monoxide and hydrogen (made by passing steam and oxygen through the

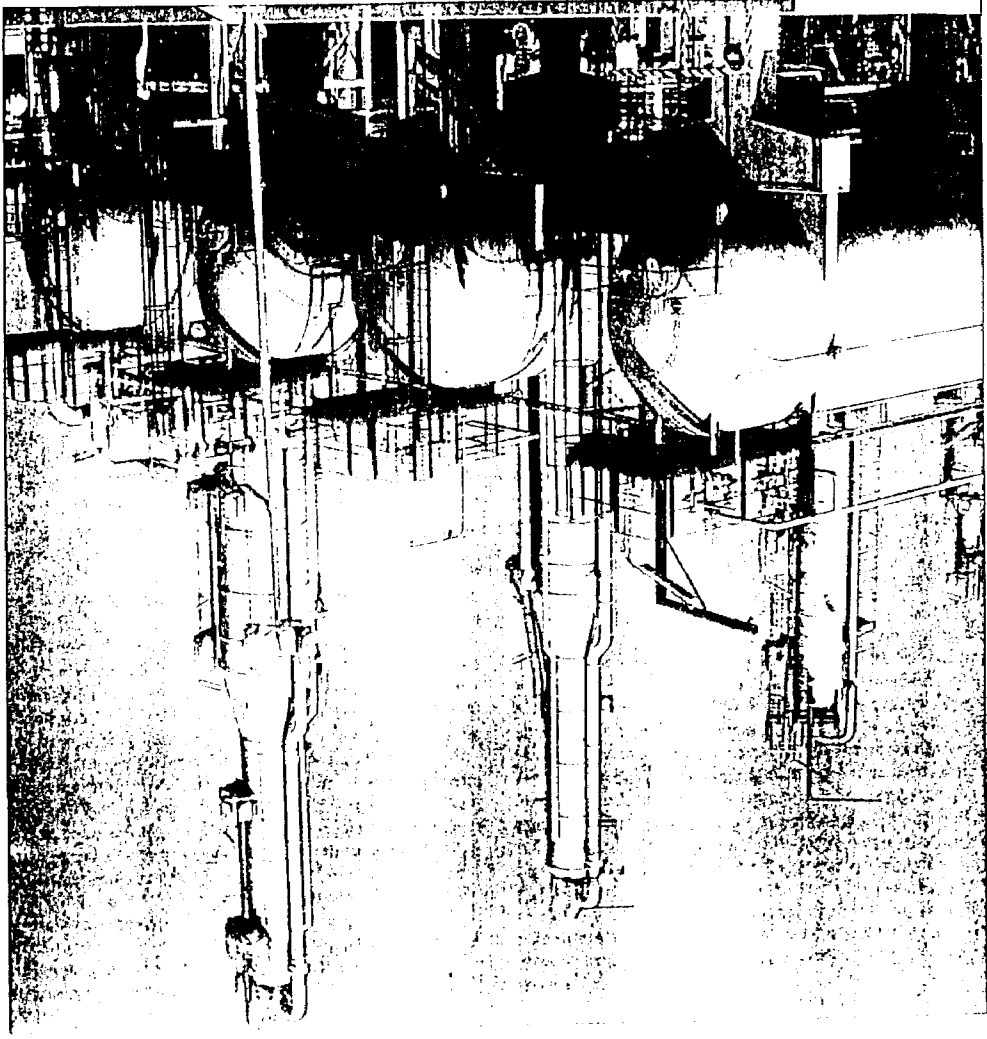


Fig 4 Sasol converts coal into fuels and raw materials for industry

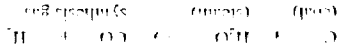
method. The volatiles serving SASOL II and III are among the lightest gases. The reaction may be adjusted to change the proportions of petroleum and diesel type fuels. Chemists and engineers at SASOL have modified and developed the original Fischer-Tropsch process to such an extent that it is now more fully called the

General industry
Coal is widely used in small scale industrial steam raising and other applications. It is also gasified and used for chemical manufacture.

Alkali, who operate one of the world's largest explosive factories at Moshalomon, some 10 km to the east of Johannesburg, uses coal as a feedstock to make ammonium nitrate and a range of chemicals.

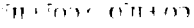
The Kruun million tonne-a-year complex sited at Langlaagte requires lump coal. Small coal is burnt to generate steam and at SASOL, a certain amount of electricity. All the coal used by SASOL is excavated by underground

plex in the world's largest coal-based ammonium nitrate plant. The capacity of the plant has been increased and modified, but diesel engines are used and the ammonium nitrate plants produce nitric acid, ammonium nitrate, urea, methanol and liquid carbon dioxide. Annually about 500,000 tonnes of coal are used to generate 2,000 MW of power.



2) methane gas

Raw synthesis gas containing 20% carbon monoxide, 27% hydrogen and 73% carbon dioxide and various impurities, e.g. hydrocarbons, sulphides, is compressed to 3.0 MPa and the hydrogen sulphide is removed by physical absorption in methanol at -20 °C. The purified raw gas is then compressed further to 5.0 MPa. It is then passed through the C-1 shift converter where the following reaction takes place:



The gas mixture is cooled to remove most of the water and it is then contacted with methanol at approximately -20 °C and pressure of 5.0 MPa. The carbon dioxide dissolves in the methanol leaving a gas stream consisting essentially of hydrogen with small amounts of inert gases, i.e. carbon monoxide, nitrogen and methane. The carbon dioxide is recovered from the methanol by reducing the pressure and is used either to make urea by reaction with ammonia, or bled off under pressure and used in the manufacture of car-

The hydrogen gas contains about 10% of C_2 and by light of methane. These are removed by molecular sieves and the gas is then further purified by washing with liquid nitrogen. This condenses out the inert gases and allows the hydrogen to pass through. In the process some methane up to a molar ratio of 3:1 by hydrogen with nitrogen is vaporized with the hydrogen. This mixture is made up to a molar ratio of 3:1 by hydrogen with nitrogen gas from the nitrogen compressor and fed to the synthesis gas compressor where the pressure is raised to 22.000 kPa. It is passed over the ammonia converter catalyst, which is essentially iron promoted with trace elements such as potassium, calcium and aluminium, to give the reaction is an equilibrium one.



It would be expected that high pressures and low temperatures would push the equilibrium to the right. In practice,

Coal used in the general trade has to be well sized and, in making leaving the liquid nitrogen wash, where the volume is made up from the nitrogen/hydrogen dense out the ammonia and recycled to the compressor. About 15% of the gases leaving the reactor are collected to form a gas between 100 and 500 °C. This gives a concentration of urea are normally run at 20 MPa and 150 °C and recycle rates are extremely great. A compromise is reached between design capacity of 200,000 tonnes per annum is modified and because the capital costs of operating at very high pressures because the temperature affects the kinetics of the reaction

Domestic usage
In spite of the generally warm weather in South Africa, 4 million tons are used for domestic cooking and heating. C-10 smokeless fuel for stoves. The last named is a product in or smokeless fuel for stoves. The last named is a product in which the coal is heated to remove the tar and gases (the solid residue, known as "semi-coke" or "char", is sold as a domestic smokeless fuel). Lump coals are supplied to this market.

Exports
The export market has been an area of major growth in South African coal industry. In the 20 year period from 1952 to 1972, coal exports barely averaged 1.0 million tons per annum. In 1970, an agreement was made with the Japanese steel mills to provide 2.5 million tons per annum of specially washed "low-ash coal". The tonnage was sufficient to justify the construction of the port of Richards Bay, which was officially opened in 1976. Originally connected with a capacity of about 1.1 million tons per annum, exports have grown rapidly and reached a peak of some 4.5 million tons per annum. By 1988 exports were just under 10 million tons per annum. The South African economy is heavily dependent on coal and will remain so for many years to come. As recovery of coal reserves diminish, the demand for coal is likely to increase and the possibility of "black diamonds" will become more and more apparent.

Acknowledgement

Information of the coal mining industry was kindly provided by the Chamber of Mines.

Not in Our Backyard

Outraged residents force a cutback in plans for a huge mine excavation in Germany's Rhineland

by MICHAEL S. SERRILL

AS THE RHEINRAUN OPEN-FACE COAL mine in Germany's industrial heartland of North Rhine-Westphalia, the great bucket-wheel excavators toil from dawn to dusk, tearing out of the ground 240,000 tons of lignite coal a day, spilling it into 13,000 dump trucks. The coal goes to fire up the plants of RWE, Germany's largest producer of electrical power. It also keeps the Rhineland's factories running. But the mining and coal-firing operations also do enormous environmental harm—filling the air with carbon dioxide pollution, lowering the regional water table and uprooting thousands of people from their homes.

So when Rheinbraun AG, RWE's mining subsidiary, formally proposed eight years ago that a new mine, to be called Garzweiler II, be started up nearby, the project quickly became the most controversial in postwar Germany. Last week opponents of the new mine claimed partial victory: when North Rhine-Westphalia's Social Democratic (S.P.D.) government, already wounded by the Garzweiler issue in May elections, agreed to curtail and delay the project. The compromise allows the S.P.D. to form a coalition government with the small Green Party, which helped deny the S.P.D. an absolute majority in the state parliament for the first time in 35 years by doubling its vote share from 5% to 10%. The coalition could be a prelude to an S.P.D.-Green combination in national elections, due in 1998.

The defeat of Garzweiler II—if that is the final result—owes as much to an unprecedented community uprising as it does to the Greens. At its largest, the original Garzweiler strip mine, about 20 km southwest of Düsseldorf, was a huge scar in the earth covering 70 sq km, half the area of Bonn; about 30% of it has now been filled in. Though Garzweiler has been dubbed "Europe's biggest hole" by the German media, that distinction actually belongs to Rheinbraun's 85-sq-km pit mine at Hambach, 10 km away. Since lignite mining began in the region in 1949, it has displaced 30,000 people.

The looming addition of Garzweiler II, under the original plan, would have covered 83 sq km and literally cut the ground from under 5,000 more people and a dozen

villages, some of them dating back 1,000 years. The locals—at least those who do not earn their living from mining—want no part of it, and have launched a massive grass-roots movement in protest. Three weeks ago, one group took their plant afloat, boarding the ship *Godesia* to broadcast their arguments up and down the Rhine. Their battle cry: "Garzweiler II is economically senseless, ecologically disastrous and socially irresponsible."

"This is expulsion in the middle of Europe in the year 1995," cries Gisela Irving, 59, whose village of Holzweiler would be swallowed up by the mine. "It will be 48

Environmentalists respond that Rheinbraun, which digs 120 million tons of coal a year, could still produce 80 million tons without Garzweiler II—and that amount, with the ongoing shift from industrial to service jobs plus energy conservation and development of alternative fuels, might be enough.

The compromise reached last week would seek to reduce the size of the Garzweiler II site by two-thirds, at least initially, so that 2,000 rather than 3,000 people would be uprooted. And the plan will not be implemented until a court decides whether the state parliament needs to approve it, which could take three years. The first resettlement of villagers in the path of the mine is unlikely until after the year 2000, giving the Greens five years, in the words of spokesperson Gerd Mai, "to prove the mine project is superfluous."

Rheinbraun registered its "disappointment and indignation" with the deal, saying the delay will result in a "drastic, unac-

GIANT excavators at Garzweiler dig 240,000 tons of coal a day

sq km of apocalypse. This is a violation of human rights." Provincial authorities received 19,000 letters in opposition to Garzweiler II. All six Catholic parishes in the path of the excavators passed a resolution refusing to move, confronting Rheinbraun with the embarrassing exercise of having to seize their land.

Backers of the project say opponents are unrealistic—especially since 40,000 jobs in the Rhineland depend directly or indirectly on the coal industry. Moreover, there is a moratorium on new nuclear-power plants. "An industrial nation like Germany cannot shut off nuclear energy and give up coal at the same time," warns Rudolf Scharping, national S.P.D. chairman. "This is romantic, but surely not a feasible, economically supportable and ecologically responsible policy."

ceptable limitation of output." The miners' union staged a brief work stoppage and threatened to march on the state parliament at Düsseldorf. In the anti-Garzweiler camp, some are unhappy that the new mine was not canceled outright. But "we can live with the compromise," says resident Gisela Irving. "Our chances are considerably higher with the Greens in the government than outside it. The mood here is full of hope." Which is better than a widespread sinking feeling.

Reported by Rhea Schoenthal/Bonn

COAL: The mineral for all seasons

Spectrum, October 1995

By G.C. Gerrans & D. Horsfall

Coal is a complex chemical material which reacts violently with oxygen to give off heat energy. The main use of coal is as a fuel. In thermal power stations coal is used to boil water to give steam which in turn makes turbines rotate to generate electricity. (Page 42)

Not in our backyard

*Outraged residents force a cutback in plans for a huge
mine excavation in Germany's Rhineland*

Time, July 10, 1995

By Michael S. Serrill

At the Garzweiler coal mine in Germany's northern Rhine region the heavy machines work all day, mining 240,000 tons of coal every 12 hours. The coal goes to fire up the plants of Rhine West Electricity (RWE), Germany's biggest producer of electrical power, which keeps the Rhineland's factories running. But the coal-burning does enormous harm to the environment - filling the air with carbon dioxide pollution and uprooting many people from their homes.

Rheinbraun - a local mining company - proposed to start up a new mine nearby called Garzweiler II. The project soon became a big problem for many Germans. Those fighting against the mine won a victory last week because the Social Democratic (S.P.D) who ruled the area agreed last week to stop the project.

The defeat of Garzweiler II owes much to the community resistance to the project. The first Garzweiler mine, about 20km south-west of Dusseldorf, was very ugly and covered 70 square kilometres. Worse than this, since coal mining began in 1949, 30,000 people have been forced to leave their homes.

Garzweiler II, if allowed, would have covered 48 square kilometres and forced another 8,000 people to move from their homes. It would have destroyed a dozen villages, some a thousand years old. The locals - at least those who do not earn money from the mine - have resisted strongly and showed massive grass-roots protest. One group even went on a boat on the Rhine and broadcast their dissatisfaction.

A resident of the area, Gisela Irving said it was "forced removal" and his entire village of Holzweiler would have been swallowed up by the mine. He said that this was against his human rights and had to be stopped. Local authorities received 19,000 letters complaining about Garzweiler II. All six Catholic churches in the path of the mine refused to move forcing the authorities to take their land by force.

People who support the project say those who oppose the project are not sensible - mainly because 40,000 jobs in the Rhineland depend on the coal industry. The problem is made worse since Germany has stopped allowing for nuclear power stations to exist as another form of energy production. Rudolf Scharping, a spokesperson for S.P.D. says, "an industrial nation like Germany cannot shut off nuclear energy and give up coal at the same time." He also said that it is also not economically possible or environmentally responsible.

Environmentalists respond that their region could produce 80 million tons of coal a year without Garzweiler II and this together with alternative energy sources such as solar power and wind power should be enough.

The decision last week will reduce the size of the Garzweiler II mine by two-thirds so that 3,000 instead of 8,000 people would be forced to move. What may delay this development is a court has still to approve the forced removal which could take up to three years.

The S.P.D. were very upset with last week's deal saying that it reduced the mine's output to a large extent. The miners', whose jobs were at stake, marched on the Dusseldorf state parliament trying to get local government to reopen the mine. The environmentalists such as Gisela Irving said that although he was not entirely happy he felt that the negotiations meant their homes were safe for the moment.

P E N C E

MAN BITES SHARK

Scuba divers safe from shark attacks by use of electrical field

By PETER HAWTHORNE DURBAN

PEOPLE ARE MORE OF A THREAT TO sharks than vice versa. Shark attacks average only 70-100 each year, and the number of humans actually killed is much lower. Many fewer, in all probability, than the number of sharks who give their all to supply soup for a medium-sized Chinese restaurant each week. But the sight of a dorsal fin slicing through the water can still clear a holiday beach faster than you can say "Jaws," and in some waters the danger to surfers and divers is very real.

The good news for those at risk is that there's now a new way to keep the sharks away. It's called the POD—short for Protective Oceanic Device—and it has been developed by South Africa's Durban-based Natal Sharks Board, one of the world's foremost shark research institutes. The portable POD protects swimmers or divers by surrounding them with an electronic field that even the most dangerous sharks appear unwilling to enter.

Scientists have battled for years to find an effective shark repellent. During World War II the quest took on a particular urgency to protect downed aviators or sailors forced to abandon ship. Various chemical repellents and detergents were tried, but they quickly dispersed in the water.

Physical barriers appeared to be the only effective measure and since the 1950s attack-prone beach resorts around the world have protected swimmers by erecting elaborate anti-shark nets. Another approach pursued in South Africa and elsewhere involved experiments with electric force fields. But cumbersome, heavy-duty cable barriers encircling the beaches were found to be impractical and unable to withstand heavy seas. There was also a danger that the electrical charge required to zap sharks might do the same to humans.

Enter the POD system, discovered almost by chance by Graham Charter, chief executive officer of the Natal Sharks Board. During experiments on sharks that had been snagged in the barrier nets, Charter found that their responses to relatively small electrical impulses were surprising. The shark's unique sensory system in its snout, Charter found, could respond to extremely low electrical voltage signals over large distances.

That insight led to the design of the POD, to be used initially for the protection of scuba-drivers. It comprises a 90-watt portable power pack and, separated by a 1.5-m cable, a probe attached to one of its

TERROR OF THE DEEP: Any shark as long as a man is dangerous, but most fearsome is the great white, left, which can reach 11 m.

B. B. BONE-ARDA



The "Protective Oceanic Device" or POD, generates a low-voltage electrical field that is harmless to humans but well beyond the pain tolerance level of sensitive shark snouts.

and Valerie Taylor, the Australian husband and wife team whose documentary on the much feared great white—*Blue Waters, White Death*—has become a nature film classic. In 1994 they took the device to Milne Bay, in Papua New Guinea, where offal was thrown into the sea to send a group of sharks into a feeding frenzy. They then equipped themselves with a POD apiece, switched on and swam into the middle of the melee—a normally foolhardy activity without the protection of a shark cage. "The sharks instantly turned and left the food and the area," says Ivan Slabbert, South African managing director for the POD.

Last March the Taylors used the POD during the shooting of their latest documentary on great whites off Neptune Island, South Australia. After their first encounters with the activated unit, claims Slabbert, the sharks maintained a respectful distance. Even when the device was switched off the Taylors were able to film the great whites in open water without the restrictions of a cage. Unconditionally endorsing the protective system, the Taylors say it is a "huge step forward for all

those who work and play where confrontation with a shark is possible."

Nevertheless George H. Burgess, director of the International Shark Attack File at the University of Florida's Museum of Natural History, cautions that the POD has limited usage. "It's a great first step but it isn't the savior we are looking for," he says. South African Sharks Board officials believe, however, that the POD could soon be attached to surfboards and modified for swimmers. Deputy director Norman Wynne says the board is already receiving inquiries from life jacket and life raft suppliers and from abalone divers. An adaptation of the POD system might also replace shark nets in some coastal areas.

For serious surfers and scuba divers the introduction of the POD means that areas that have previously been considered too risky may be opened up for recreation. Bruce Eldridge, who was attacked by a great white and seriously injured in 1985 while surfing at Umhlobozini, south of Durban, is one of those excited about the POD's possibilities. Still surfing at 30, his right leg carrying the scars of his mauling, Eldridge is eyeing a nearby river mouth area where the surf is superb but sharks are known to prowl. —With reporting by Mairi Ben Brahim/London

How to Avoid Being the Main Dish in a Feeding

CONTRARY TO THEIR HOLLYWOOD IMAGE, SHARKS SELDOM attack swimmers—no more than 100 such attacks are reported annually, resulting in fewer than 15 deaths. Although reports suggest that shark-human encounters are rising, experts attribute the increase to larger numbers of swimmers and better reporting from remote Third World areas. Still, shark experts offer a few tips for minimizing the chances of inadvertently becoming a shark snack:

- Swim in groups. Sharks are more likely to attack a lone swimmer or individual surfer.
- Avoid the water during darkness when sharks have a competitive sensory advantage.
- Do not enter the water if bleeding from a cut or if menstruating; their olfactory ability is acute.
- Remove shiny jewelry that can reflect light in a way that resembles the scales of a fish—thus attracting sharks.
- Do not go into the water in areas where sport fishermen are trailing bait or in waters containing garbage or sewage.

- Be cautious when entering murky water. Sharks are able to see extremely well.
- Refrain from vigorous splashing, which may be interpreted as a fish in distress.
- Avoid areas of steep dropoffs, which tend to be shark aggregation points for sharks.



Man bites shark!

Time, February 3, 1997.

*A new power pack keeps scuba divers safe from shark attack
inside a protected electrical field*

Reported by Peter Hawthorne, Durban.

People are more of a danger to sharks than the other way around. There are only 70-100 shark attacks each year, and the number of people killed is very small. In fact, more sharks end up in Chinese restaurants each week. But people are still afraid of sharks and in some waters the danger to surfers and divers is very real.

The good news for those at risk is there's now a new way to keep the divers from being attacked by sharks. It's called the POD - short for Protective Oceanic Device - and it has been developed by South Africa's Natal Sharks Board. The portable POD protects swimmers by surrounding them with with an electric field that even the most dangerous sharks do not wish to enter.

Scientists have struggled for years to make such a system. During World War II there was a real need to protect airmen in the Pacific who crash landed in shark infested waters. Many chemicals and detergents were tested, but the sharks did not seem to mind.

Shark nets installed since the 1950s around South Africa's beaches seem to be the only way to protect bathers effectively. In recent years, South African scientists have done experiments involving electrifying the safety nets. The problem was that these nets were too heavy and were easily damaged in rough seas. There was also the danger that the high electrical fields needed to stun sharks may even do the same to people.

The POD system was discovered by Graham Charter, a chief researcher with the Natal Sharks Board. Charter found that sharks quickly swam away when they came near to an area of small electrical impulse. The shark's nose has a very sensitive sensory system that responds to very low electrical voltage signals over large distances.

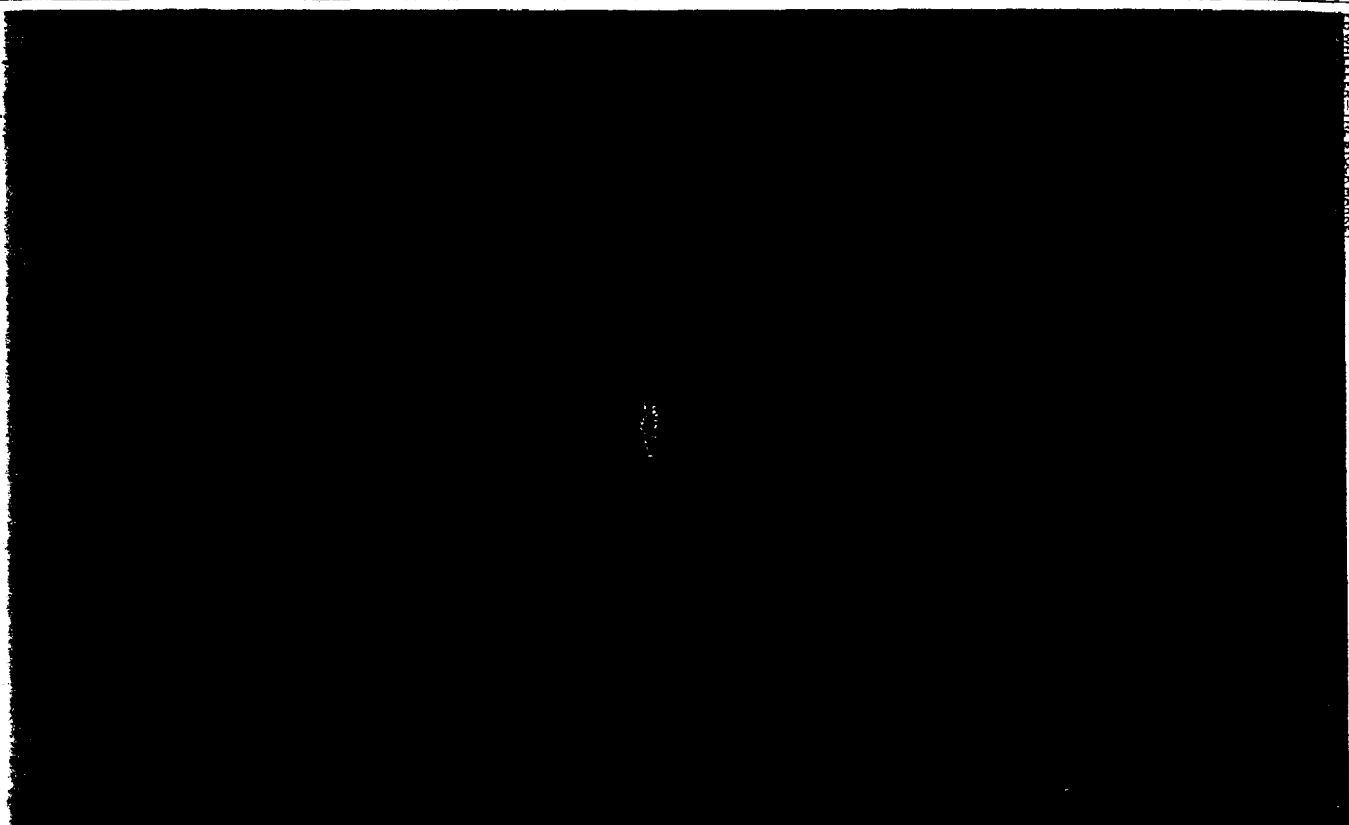
This led to the making of the POD and was first used to protect scuba-divers. The POD is a 90-volt portable power pack with a cable attached to a box on one of the diver's flippers. When switched on, the POD generates an electromagnetic field up to 7 metres around the diver. The field, which POD generates lasts up to 75 minutes before the power pack must be recharged. It is not strong enough to harm people, but sharks are quickly scared away.

Before selling POD the Natal Sharks Board let Ron and Valerie Taylor, the Australian shark experts, test the new system. In 1994 they took POD to Milne Bay, in Papua New Guinea, where blood and meat was thrown into the sea to make the sharks go crazy. Ron and Valerie then attached POD to their wetsuits and swam in the middle of the sharks. Afterwards the divers noted that, "the sharks left both the food and the area."

The Taylors used the POD in recent months when filming their latest television show near Neptune Island, South Australia. They say the sharks were too scared to come near them even when the system was switched off.

Although the results of Taylor's tests are good news for swimmers, another scientist, George Burgess of the University of Florida says that it does have its weaknesses and should not be fully trusted. South African Shark's Board officials, however, are very satisfied with POD and that many questions about it have been asked by abalone divers and life jacket manufacturers.

For serious surfers and swimmers POD may mean that areas thought to be too dangerous could now be opened up for peoples' leisure activities. Bruce Eldridge, who was attacked by a great white shark in 1985 while surfing near Umbogintwini, south of Durban, is one of those who are happy about the POD. Still surfing after his attack experience, he is looking at surfing in a nearby river mouth area where the waves are great, but so are the numbers of sharks.



Prolonged exposure to high-voltage power lines like these has been associated with increased risk of several types of human cancer

Mystery—and Maybe Danger—in the Air

A government review heightens concern about hazards of the electronic age

By PHILIP ELMER-DEWITT

Can electricity cause cancer? In a society that literally runs on electric power, the very idea seems preposterous. But for more than a decade, a growing band of scientists and journalists has pointed to studies that seem to link exposure to electromagnetic fields with increased risk of leukemia and other malignancies. The implications are unsettling, to say the least, since everyone comes into contact with such fields, which are generated by everything electrical, from power lines and antennas to personal computers and microwave ovens. Because evidence on the subject is inconclusive and often contradictory, it has been hard to decide whether concern about the health effects of electricity is legitimate—or the worst kind of paranoia.

Now the alarmists have gained some qualified support from the U.S. Environmental Protection Agency. In the executive summary of a new scientific review, released in draft form late last week, the EPA has put forward what amounts to the most serious government warning to date. The agency tentatively concludes that scientific

evidence "suggests a causal link" between extremely low-frequency electromagnetic fields—those having very long wavelengths—and leukemia, lymphoma and brain cancer. While the report falls short of classifying ELF fields as probable carcinogens, it does identify the common 60-hertz magnetic field as "a possible, but not proven, cause of cancer in humans."

The report is no reason to panic—or even to lose sleep. If there is a cancer risk, it is a small one. The evidence is still so controversial that the draft stirred a great deal of debate within the Bush Administration, and the EPA released it over strong objections from the Pentagon and the White House. But now no one can deny that the issue must be taken seriously and that much more research is needed.

At the heart of the debate is a simple and well-understood physical phenomenon: when an electric current passes through a wire, it generates an electromagnetic field that exerts forces on surrounding objects. For many years, scientists dismissed any suggestion that such forces might be harmful, primarily because they are so extraordinarily weak. The ELF mag-

netic field generated by a video terminal measures only a few milligauss, or about one-hundredth the strength of the earth's own magnetic field. The electric fields surrounding a power line can be as high as 10 kilovolts per meter, but the corresponding field induced in human cells will be only about 1 millivolt per meter. This is far less than the electric fields that the cells themselves generate.

How could such minuscule forces pose a health danger? The consensus used to be that they could not, and for decades scientists concentrated on more powerful kinds of radiation, like X rays, that pack sufficient wallop to knock electrons out of the molecules that make up the human body. Such "ionizing" radiations have been clearly linked to increased cancer risks, and there are regulations to control emissions.

Doubts about weak, so-called nonionizing radiation began to grow in 1979, when a study of cancer rates among Colorado schoolchildren found that those who lived near power lines had two to three times as great a chance of developing cancer. The link seemed so unlikely that when power companies paid to have the original

Health

study replicated, most scientists expected the results to be negative. In fact, the subsequent study supported the original findings. It has since been buttressed by reports showing increased cancer rates among electrical workers.

While many experts still express skepticism, there has been a definite shift of attitude in the scientific community about the possible health effects of electromagnetic fields. As a recent series in *Science* magazine made clear, "In the 1970's [the link] seemed certain," the articles concluded. "Now it's a legitimate open question."

But epidemiological studies, which find statistical associations between sets of data, do not prove cause and effect. Though there is a body of laboratory work showing that exposure to ELF fields can have biological effects on animal tissues, a mechanism by which those effects could lead to cancerous growths has not been found.

The Pentagon is far from persuaded. In a blistering 33-page critique of the EPA report, Air Force scientists charge its authors with having "biased the entire document" toward proving a link. "Our reviewers are convinced that there is no suggestion that [electromagnetic fields] present in the environment induce or promote cancer," the Air Force concludes. "It is astonishing that the EPA would lend its imprimatur on this report." The Pentagon's concern is understandable. There is hardly a unit of the modern military that does not depend on the heavy use of some kind of electronic equipment, from huge ground-based radar towers to the defense systems built into every warship and plane.

Several Administration officials are also skeptical about the EPA's conclusions. Last year the draft language classifying ELF fields as a "probable carcinogen" was deleted from an earlier version of the EPA report after it was reviewed by the White House. At the time, the EPA denied that it was pressured into dropping the offending words.

This time it is clear that the White House is hoping for a more balanced presentation of the evidence. The draft's release was reportedly delayed at the request of Allan Bromley, President Bush's science adviser, who asked that it be reviewed by another scientific panel and prefaced with a statement that qualifies the conclusions. In an interview with *TIME*, Bromley made it plain that he believes the EPA's findings of a "positive association" between electromagnetic fields and childhood cancer are "quite incorrect." "There's no scientific basis for that statement at all," says Bromley. "What we're doing is unnecessarily frightening millions of parents."

The stakes are high. This week a study in the *American Journal of Industrial Medicine* reports a steep rise in brain-cancer rates over the past dozen years. If the increased incidence of such cancers could be



Is there danger in the glowing screens?

linked to electromagnetism in the home or workplace, liability suits could clog the courts. Property values near power lines and electric substations are plummeting. If the utilities have to bury or reroute those systems, the cost of doing business could take a sharp jump.

How serious is the risk from electromagnetic fields? Compared with some of the other dangers people take for granted—driving a car on New Year's Eve, for example—the odds of being afflicted with some of the cancers associated with electromagnetism are rather small. Brain cancer is a rare disease. Only 3.1 cases per 100,000 Americans were reported in 1986. In the most worrisome studies, the risk of developing such a cancer appears to double or triple

because of ELF fields. By contrast, the risk of lung cancer for a chain smoker is 20 times as great as it is for the public at large.

But there is a difference between a smoker who ignores the Surgeon General's warning and someone who develops cancer passively just by being born into the electronic age. People live near power lines and work with their noses in computer display screens because those things are part and parcel of the times. Everyone deserves at the very least a rough sense of what danger such exposure brings.

More study is essential. The bulk of the research being conducted on the health effects of electromagnetic radiation—at a cost of some \$10 million a year—is paid for by the U.S. Department of Energy and the Electric Power Research Institute, neither of which is a disinterested party. The EPA used to conduct its own studies, but funding for its research was cut off by the Reagan Administration. Perhaps the best candidate for new funding would be the National Institutes for Health. The research should examine not only the effects of ELF fields but also those of less-studied radiation having shorter wavelengths, such as radio and TV waves.

Meanwhile, ordinary citizens can exercise what is called prudent avoidance—doing relatively easy things to minimize a possible risk. This is not the time to sell, tear apart or rebuild a home. But it might make sense to shift a child's bed away from the electric line that brings power to the house. Or to move the telephone answering machine away from the head of the bed. It isn't hard to take a step back from the TV or computer screen, and it could make a big difference in the long run. —*Reported by Dick Thompson/Washington*

Probably no individual has collected more information about extremely low-frequency fields—or done more to sound the alarm about the dangers they may pose—than Louis Siesin, editor of a newsletter called *Microwave News*. Here is his ranking of the worst hazards—and some advice:



1. High-tension electric transmission lines. Strung along high towers, these lines carry large amounts of electricity over long distances. Homes, schools and playgrounds should not be built anywhere near them.



2. Electric distribution lines. The kind that carry current down local streets, they generate fields less powerful than those from transmission lines. But distribution wires are much closer to most homes. Utilities can sometimes bury or relocate the lines.



3. Electric blankets. They lie right on top of the body for hours at a time. It's a good idea to warm the bed and then unplug the blanket before going to sleep—or, better still, get a quilt instead.



4. Video-display terminals. People spend whole workdays close to computer screens. They should stay 75 cm (30 in.) from the front and 90 cm (3 ft.) from the sides and back. The same rules apply for TVs.



5. Bedside appliances. Electric clocks and fans usually run continuously. They should be kept at least 75 cm (30 in.) from the head.



6. Other appliances. Shavers, hair dryers, can openers and microwave ovens all generate powerful fields, and people should be careful to use them for only short periods of time.

TIME Chart

Mystery - and maybe danger - in the air

By Philip Elmer-Dewitt

Can electricity cause cancer? In a society that uses a lot of electrical power, the idea seems stupid. But some scientists believe that the fields around current-carrying conductors may increase a person's risk of having cancer. The thought of developing cancer is frightening, since everyone comes near such fields, which are made by everything from powerlines to microwave ovens.

The Environmental Protection Agency (EPA) of the United States (America) released a report last week which warns the public of the dangers of coming within very low-frequency electromagnetic fields. Although the EPA does not say for certain that there is a definite link between cancer and the electromagnetic fields.

The report, however, is no reason to lose sleep over since the possibility of developing cancer is very small. There is much disagreement among scientists and government officials as to whether such a risk does exist, but there is a need to conduct further research on the matter.

At the heart of the debate is a simple and well-understood physical principle: when an electric current passes through a wire, it generates an electromagnetic field that exerts forces on nearby objects. Scientists in the past have not thought of these forces as being harmful because they are so weak. The question is now asked: "How could such small forces be such a health danger?"

In past years scientists have concentrated their work on X rays because these powerful forms of radiation are known to be very harmful and cancer causing. For this reason, regulations are in place to prevent people from being harmed.

Concern about weak radiation such as low-frequency electromagnetic fields began to grow in 1979, when Colorado schoolchildren who lived near powerlines were found to develop cancer two to three times faster than children elsewhere. Power companies accused of causing harm asked scientists to repeat the studies and the same outcome resulted. In fact, the power companies were more worried that they would now have to accept the results because more and more cases of cancer were being reported among electrical workers.

From the early 1980s many scientists started to say that these small electromagnetic fields were guilty of causing cancer. Reports were even to be found in the magazine *Science* which writes that such reports in the past were silly, but: "Now it's an open question." With this being said, however, nobody is saying for sure that the electromagnetic low-frequency fields are guilty of causing cancer. There seems to be a lot of evidence for both sides of the argument.

The Pentagon (America's army command), for one, are saying that the EPA report is nonsense! They have recently written a 33-page report saying that the EPA only present a one-sided argument. They finish their report with these words: "Our scientists say there is no link between electromagnetic fields and cancer in people." The standpoint of the army is understandable since all their military equipment such as electronic apparatus and radar towers depend upon electricity.

The government nonetheless want to see a fair presentation of the evidence. Right now there are results of experiments from the two groups of scientists. The question is who should be believed? To help the government in making the right conclusions about the "possible dangers" the science adviser to the president, Allan Bromley, has asked for more time so that a third opinion from a respected group of scientists may be obtained. At the moment, Bromley told *Time* that he thinks the link between cancer and low - frequency electromagnetic radiation was incorrect and that the EPA report was only, "frightening millions of parents."

If it is proved that such radiation causes cancer then cancer-suffers may claim enormous sums of money in the law courts from power companies, computer companies and their places of work. Furthermore, home prices near power lines are also going down and power companies may be forced to install these lines below ground which is very expensive and people of the community will now have to pay more for their electricity.

Speaking about the dangers of electromagnetic fields, it is said by one group of scientists that hardly any risk exists. Brain cancer, for example, does not often occur. Only 3.1 cases per 100,000 Americans were reported in 1986. Another group of scientists disagree: They say that the risk of developing such a cancer doubles because of the electromagnetic low frequency fields.

Yet, we all live in an electronic age and there is no escaping powerlines or computers. The best then for each of us, no matter what the scientists say, is to know what risks we are taking. More study is necessary and \$10 million are paid out each year for research by the U.S. Department of Energy.

Ordinary people who are waiting for the outcome of the debate are well advised to take several steps to protect themselves and their families. For example, parents might shift their child's bed away from the electric line bringing power to the house. Or move the telephone answering machine away from the top-end of the bed. It isn't hard to take a step back from the TV or computer screen, and could make a big difference in the future.
