PERCEPTIONS OF SCIENCE AS DETERMINANTS OF THE RECEIVED CURRICULUM IN SCIENCE, IN BLACK SCHOOLS, IN THE UMLAZI AREA

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ABSTRACT

The value of teachers' perceptions of science is noted, given that teachers play an active part in implementing curricula. The possibility that teacher's perceptions of science may be different from the image of science portrayed in the official curriculum is considered. Given that during the apartheid era, education was dominated both politically and culturally by one group, objections to the ideological-cultural dimension of the official curriculum were expected.

An exposition of the philosophical basis for science teaching and curriculum development is attempted. A process model of curriculum is adopted as it is seen as more effective in portraying the political context of curriculum practice. It is argued that both curriculum practice and the notion of being "scientific" are not objective but depend on the dominant culture. Therefore, there is a need to be open-minded and eclectic about the notion of being "scientific".

An attempt is made to identify teachers' perceptions rather than test the teachers' perceptions against a given norm. In this context a qualitative approach is attempted in identifying teachers perceptions of science by using unstructured and open-ended interviews. A content analysis of the overarching philosophical view in prescribed books and syllabus documents is attempted. Findings are that, broadly speaking teachers perceptions of science were not dissimilar from those in the

official curriculum when the study was conducted.

In making recommendations for curriculum development it is noted that teachers views need to be accommodated. However including teachers in curriculum development should go hand in hand with workshops to raise teachers awareness of the issues involved. It is also argued that there is a need for separate curricula for those who go on to be scientists as well as those who need science for their general education.

DECLARATION

I, BENEDICT ERIC THANDINKOSI SIBISI, declare that

"Perceptions of science as determinants of the Received Curriculum in Science, in Black schools,in the Umlazi area"

is my own work and that all sources I have used or quoted have been indicated and acknowledged by means of complete references.

DURBAN

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CHAPTER 1

1.1 BACKGROUND TO THE STUDY

Previously as a lecturer at an in-service training college, and more recently as a Physical Science Subject Advisor, the researcher has met Physical Science teachers from many parts of KwaZulu. During such encounters the topic of "problems in the teaching of Physical Science" arose frequently. The first category of problems that often gets mentioned is the inadequacy of facilities, resources and staffing. This inadequacy results at least partly from a government policy of unequal educational provision for different racial groups, that used to be pursued in South Africa.

For example problems such as overcrowding in class, shortage of suitably qualified teachers and shortage of books laboratories and equipment were found to be patently evident during school visits by the researcher. Between February 17 and February 28 1992, 13 schools offering senior Physical Science in KwaMashu were visited by the present author. It was found that 12 of the 13 schools had more than 70 pupils in some of their senior Physical Science classes (standard 8, 9 and 10) Further findings were that; only 3 of the 13 senior Physical Science teachers had degrees in science with only 3 schools having reasonably equipped and functioning laboratories. In this case "reasonably equipped and functioning laboratories" are defined (somewhat arbitrarily and debatably) as able to perform at least 50% of the prescribed practical work.(It can also be added that KwaMashu is an urban area, and hence teachers there are better qualified than average.)

Problems such as those mentioned above are often cited by teachers as impediments in science education in Black schools. It is interesting to note that such crucial problems are merely stated but seldom debated, giving the impression of a general consensus of opinion about their existence for Black teachers. It may be deduced that they are regarded by Physical Science teachers as incidental and patent rather than central and debatable. Given that racial segregation and unequal provision of facilities in general was official government policy not very long ago (at least until 1990), is there anyone who would seriously dispute inequality of educational provision for different races in South Africa?

At a more fundamental level, teachers frequently complain that the science syllabi, books and work programmes, (the "Official Curriculum",) are not adequately designed to meet the educational needs of Black children. They also complain that they are not consulted during curriculum decision-making. Complaints such as these led the researcher to believe that some Black teachers felt that they had something to contribute to curriculum development. In any case the researcher found himself attracted to ideas relating to democratizing curriculum decision-making (MacDonald, 1974) This led to the decision to interview teachers to find out what they would contribute given a chance.

Further, the complaint that the "Official Curriculum" is not adequately designed to meet the educational needs of Black children, left the researcher wondering if the content of the curriculum itself is perceived as inadequate; as opposed to education being under-resourced and underfunded in the context of otherwise acceptable curricula. If the curriculum is perceived as adequate then solving problems related to funding and resources such as teacher qualifications, size of the classes and adequate science equipment would be seen as the way to solve "problems in the teaching of Physical Science". On the other hand, improving funding and other resources would not necessarily lead to teacher satisfaction if they are fundamentally dissatisfied with the curriculum.

This leads to a focus on the philosophical aspects of the "Official Curriculum" as opposed to the mere provision of resources. How does the "Official Curriculum", in the form of syllabi, work programs and prescribed books, present science? Is this presentation congruent with teachers' perception of science? If so, would a solution of the (obvious) problems of size of classes, teacher qualifications and resources result in teacher satisfaction with the quality of education? Are teachers' perceptions of science in line with current views about science education in the western world?

Answering the above questions entails identifying teachers' perceptions of science. The way in which teachers perceive science may be deduced initially from what motivated them to study science. The assumption here is that, given a choice of several subjects, a person will only study a given subject if s/he finds it either interesting on its own or s/he perceives it as having a certain utilitarian value.

Further one would expect science teachers to have opinions about the following philosophical questions:

(1) What do they regard as scientific knowledge?

(2) Why is science taught at school?

(3) Can science be understood by children who are not "gifted"?

(4) Is there a need for people to be "science literate"?

(5) Is science only confined to certain cultures?

The literature on science education and the philosophy of science revolves mainly around getting answers to questions such as these (Driver, 1983; Feyerabend, 1988; Kuhn, 1962; Popper, 1959; Toulmmin, 1961). Even in popular writing about science or science education such questions are raised (Newsweek, 29/11/93, 46) Questions such as those mentioned above would help to elicit what teachers regard as important in Science, in Science Education as well as in Science Curriculum Development. They may also give us an idea of the kind of input we can expect if teachers are actively involved as stakeholders in curriculum design, development and evaluation, as they hopefully will be in the near future.

Similarly, this study purports to reveal that the "Official Curriculum ", in the form of syllabi work programs and prescribed books, has a specific position on these philosophical questions. It would then be interesting to note to what extent assumptions held by teachers and those made in the "Official Curriculum" are congruent. An analysis of the extent to which these are in line with current philosophical views about the nature of science and science education, as revealed through a literature review, should yield interesting results.

1.2 MOTIVATION FOR THE STUDY

In a democracy, curricula should reflect the wishes of stakeholders. Stakeholders are those who have an interest and/or are affected directly or indirectly by school curricula. Teachers are stakeholders in that they are the ones who implement curricula at schools. Teachers are not the only stakeholders in this context, but they are in the "front line" of education in industrialised societies. Their views and concerns therefore warrant careful consideration in any proposed educational reforms. Hence, it is necessary to identify epistemological assumptions about the nature of science and science teaching among science teachers in this country, in order to design curricula that can accommodate teachers' views. Such assumptions made by the teachers can then be compared with those of other stakeholders. Appropriate compromises would then be made in curriculum design in an attempt to accommodate the views of the various stakeholders.

It can be argued that curricula are never "neutral" but depend on the beliefs, values and epistemological assumptions held by those who design the curricula. Hence, this study also purports to reveal the position held in the "Official Curriculum", in the form of syllabi, work programs and prescribed books, about these philosophical questions. This is done by means of a content analysis of relevant documents and books.

It follows from the above arguments that this study should expose the congruence or lack of it between teachers' views and expectations and the views entailed in the official curriculum. An exposure of the congruence, or lack of it between epistemological assumptions about the nature of science entailed in the "Official Curriculum" and in teachers' perceptions of science should help in determining in-service training needs of teachers; where deficiencies are perceived, and also in pointing the direction in which future Science Curriculum Development should go in order to address relevant problems.

1.3 POSITION TAKEN IN THE STUDY

Given that this study aims to reveal the philosophical implications of the existing "Official Curriculum" vis-a-vis teachers' perceptions of science and science teaching,as discussed above, it then follows that the central concepts in this study are those pertaining to curriculum and curriculum development as well as the nature of science and science education.

In the second chapter the concept "curriculum" is defined and an attempt is made towards an exposition of its ramifications. The position taken is that curriculum development is an activity that should involve all stakeholders to some extent. An argument is made for democratising curriculum. In this context the study focuses on the science teacher given his/her central role in state organised education.

Focusing on science teachers and science teaching in turn leads to questions about the nature of science. The position taken is that the "nature of science" is a subject for open philosophical inquiry. It is argued that closing the inquiry about the nature of science leads to a dogmatic view in which the existence of "scientific method", "scientific objectivity" and "scientific progress" is taken for granted. The question of the possible dogmatic nature of the "Official Curriculum" is then raised <u>vis a vis</u> teacher awareness of such a possibility.

The third chapter discusses the research methodology to be used in an attempt to identify teachers' perceptions of science. The position taken in this regard is that there is no such thing as a correct perception of science. In this context there is no attempt to evaluate teachers perceptions against some yardstick of correct perception. For this reason open-ended and semistructured interviews are used in an attempt to identify views and issues raised. Responses of the teachers to interview questions are then compared and contrasted with their classroom performance in an attempt to shed further light. The assumption in this case is that teachers' perceptions of science are revealed both by what they say and what they do in class.

In chapter 4 teachers responses are analysed, grouped where this is possible and interpreted. An attempt to get a coherent story from the interviews and classroom observations is made. The aims for teaching Physical Science as given in syllabus documents are discussed. Some of salient points are raised about the way in which science is presented in prescribed textbooks. These are then related to the aims of the syllabus documents as well as teachers' perceptions of science.

In chapter 5 recommendations are made based on the extent to which the Official Curriculum is congruent with teachers' views. The need to develop a capacity for critical thinking about curriculum matters is raised. This need is raised in the context of participation of all stakeholders in democratic curriculum decision-making. Relevant course material should be developed to address this need both at pre-service and in-service levels of teacher training.

1.4 SCOPE OF THE STUDY

The study is limited to standard 8 to 10 Physical Science teachers in the Umlazi South circuit. Schwab (1969) argues that curriculum problems are "situation-specific." This study is not necessarily generalizable to other areas without taking into account possible differences in context. Nonetheless, it should offer useful pointers for further investigation in other areas.

CHAPTER 2

THEORETICAL CONSIDERATIONS

2.1 THEORETICAL PRINCIPLES RELATING TO CURRICULUM DESIGN AND DEVELOPMENT

The word "curriculum" is defined and used in many ways. Schubert (1986, 25-53) lists some of the perspectives from which the concept "curriculum" may be viewed. In discussions that follow some of these perspectives may be used or alluded to. It is therefore necessary to state them briefly:

Curriculum may be seen as content or subject matter.

For example expressions such as the "Curriculum of Zwide High School", "The B.Ed curriculum of Natal University" and so on are commonly used. According to Schubert (op cit 26):-

> Educators who use this image intend to explicate clearly the network of subjects taught, interpretations given to those subjects, prerequisite knowledge to studying certain subjects and a rationale for the ways in which all subjects at a particular level of school fit together and provide what is needed at that level.

Curriculum may be seen as a program of planned activities.
A point made here is that curriculum involves both written and unwritten **plans** for pupil activities on the part of the teachers. As Schubert (op cit 28) puts it:-

> The common thread of all these notions of planning, written or unwritten is that they are planned

> activities....Granted all these plans have purposes for which the activities are the vehicle. Yet it is the activity-what the students do-that is the curriculum.

Curriculum may be seen as intended learning outcomes.

The focus in this case is on learning outcomes rather than activities."The purpose is to be explicit and defensible regarding what is offered to students" (ibid, 29)

Curriculum as cultural reproduction.

Schubert (op cit 29) argues that:-

> In **advanced** industrial societies, it is impossible for parents who have specialized jobs themselves to teach adequately all the **complicated** capabilities that their children need. .....Thus they need special institutions to reproduce the culture for their children.(my emphasis)

In this case the basic ideology is that "curriculum... should be a reflection of the culture" (ibid) In industrial societies schools are then seen as reproducing the culture for the pupils, a task which was (or is) performed by parents as well as other relatives and associates in pre-industrial (or non-industrial) societies.The alternatives in brackets have been included deliberately and provocatively. Authors like Feyerabend (1988) and Ngubane(1990) argue that industrialization is an **option** that has been **adopted** by the "civilized world" without necessarily superseding non-industrialization in the logical connotation of the word. The intention here is to expose the assumption, adopted implicitly by Schubert (op cit), that "for all societies;

"development" entails the replacement of the **inferior state of non-industrialization** by the **superior state of industrialization"** without getting into a debate about this issue.

Curriculum may be seen as Experience

In this case Schubert (op cit, 30) argues that:-

> Curriculum as actual learning experience is an attempt to grasp what is learned rather than to take for granted that the planned intents are in fact learned. Experiences are created as learners reflect on the processes in which they engage. Curriculum is meaning experienced by the students...........

Curriculum may be seen as distinct Tasks and Concepts

In this case Schubert (op cit, 31) argues that:-

> The curriculum is seen as a set of tasks to be mastered, and they are assumed to lead to a pre-specified end. Usually, that end has specific behavioral interpretation such as learning a new task or performing an old one better......knowledge and appreciation can be analyzed in terms of the effective, cognitive, psychomotor and social concepts that characterize it.

Curriculum can be seen as an Agenda for Social Reconstruction

In this case the school is seen as equipping the child to build a new social order. The assumption here is that culture is open to critique and improvement. According to Schubert (op cit 32):-

> Based on the assumption that no culture or society is perfect and that the purpose of education is to improve it, the cultural reconstructionist sets out to build a better society....The methodology may range from teaching students desirable changes that should be made to equipping them with critical thinking

> abilities and a desire to ask and act on the question : What should be changed , how and why ?

Curriculum as "Curere" (op cit, 33)

> Instead of taking its interpretation from the race course etymology of curriculum, curere refers to the running of the race and emphasizes the individual's own capacity to reconceptualize his or her autobiography.

Such examples of the diverse ways in which the word "curriculum" is used in different contexts give the impression that the concept "curriculum" is itself nebulous. For this reason it seems to be standard practice for writers on curriculum matters to define what they mean by "curriculum" in the context of their exposition. (Lawton, 1989; Tunmer, 1981; Buckland, 1982) Indeed as Schubert (op cit, 34) puts it:-

> Could it be that staunch advocates of one image of curriculum are only examining one of many facets of the entire realm? Should we continue to cultivate a variety of images in an effort to move closer to an understanding of the whole picture of curriculum?

Examples of the issues raised above are to be found in debates on curriculum matters in the literature in South Africa. A good example of this is to be found in contrasting articles published in the South African Journal of Education.

R Tunmer (1981, 1, 30-39) proposes the definition that curriculum is "the range of compulsory and optional activities formally planned for an individual pupil by a school" (op cit 30). In proposing this definition Tunmer was objecting to the view that curriculum is "an examination of the syllabus, method and resources of a single subject discipline" He felt that this definition of curriculum was limited in that "the participants slide (often without realising it) from one level to another"(That is from syllabus to method to subject discipline) (ibid) and that this is not "a good basis for clear thinking" (ibid).

Buckland,(1982) alleges that the Tunmer analysis:-

> (a)..ignores the interrelationship between the organization of knowledge and the distribution of power in a society... (167) (b)..effectively de-politicizes education and treats curriculum as if it were a product not of social, economic, political and ideological history but based on a set of universally-valid "realms of meaning or selection of subjects" (ibid)

Citing Lawton,Buckland (1982, 167) says:

> If education is seen as a process of cultural transmission then the curriculum represents that selection from the culture which is presented to the learner at school. The selection is made at different levels by a variety of different people in a wide range of contexts, and includes activities generated by the school,or by a higher authority for the school.

For the purposes of this study we shall adopt this definition of curriculum as a "**selection from culture**" [Buckland: 1982, Lawton;1983]. According to Lawton (1983, 6)

> ..a selection from the culture (is made) bearing in mind not only the detailed analysis of the characteristics of our society as it exists at the moment, but also the application of values to that society....(Selection from the culture is therefore seen as partly) a question of reaching agreement on societal values and needs (and) also partly a question of teachers negotiating with each other and with non-teachers at the local level

This definition is adopted because it seems to be useful in analysing the impact of teachers' perceptions of science on the received curriculum.

Further, it is in this context that teacher input should be sought in curriculum development. At present (1993) there is one core syllabus for all education departments in Physical Science 8-10. This curriculum was developed by a central core-curriculum committee. It was developed without teacher consultation. The syllabi are highly prescriptive and specify not only what should be taught but also, the sequence to be followed and the instructional materials to be used. This study therefore hopes to go some way towards addressing the problems that need to be identified in designing more relevant curricula, bearing in mind teacher perceptions and situational constraints.

In analysing the impact of "selection from culture it may be useful to consider Schwab's view of curriculum as a **practical activity**.(Schwab J J 1970:The practical:A Language for Curriculum, in Schubert:The Paradigms of Curriculum.) Schwab (ibid) Considers the "commonplaces" of teacher, learner ,subject matter and milieu and the way in which these interact in practice.

With this in mind, we have ,for example,the **Official Curriculum** which refers to all the books and syllabus documents which teachers are expected to use in their education departments. We have the **Actual Curriculum** which refers to the way in which curriculum is actually presented to and perceived by the pupils.

On the one hand teachers select and present their material in specific ways. On the other hand the way in which the teachers teach will be partly determined by situational constraints such as class size, availability of relevant resources and so on. This argument seems to be applicable to all subjects offered at school. For example in South Africa science teachers do not have the same level of training and experience and may not have the same **perceptions** of science. Some teachers may view science as a subject that yields certain fundamental truths about nature, whereas others may not be interested in fundamental truths but may see science as a subject having useful technological applications. A teacher who sees science as an investigation of certain fundamental truths may pay particular attention to the section on the development of the concept of the atom (in the standard 9 syllabus). He may even wish that the syllabus allowed for a more extensive treatment of this section. A teacher who sees science as a subject that has useful technological applications may wish for a more extensive treatment of topics on electricity and magnetism and their applicability to electronics (standard 8 and 10 syllabus). Such a teacher may display a lot of enthusiasm in the treatment of such topics and may be somewhat irritated by seemingly "useless theoretical topics" like the development of the concept of the atom. The list of possible perceptions is endless; some teachers may even feel that science is unfairly portrayed as "entirely a product of western intellectuals and confined to western cultures" as opposed to a "means of adapting to the environment, found to varying degrees, in various forms in all cultures."

On the other hand pupils select and internalize in specific ways. Some pupils have educated parents and/or may well be getting encouragement and support in getting to grips with the fundamentals of science. There are also pupils who have an intrinsic interest in the science, while others pupils may see doing science as a means of getting good jobs, (as doctors engineers and so on) climbing up the social ladder and improving the lot of their poor families. The latter are clearly only interested in getting good grades in high school science and may not bother studying non examinable topics purely out of interest. Other factors such as rapport with the teacher come into play in determining pupil attitude to science.

The Received Curriculum is a result of "situation-specific" interactions among the commonplaces of teacher,learner, subject \matter and milieu (Schwab,ibid).It therefore seems that we cannot get at, or present the Received Curriculum like we can present an official curriculum document. For example we cannot really equate the "received curriculum" if we consider on the one hand a well qualified and experience teacher, in a school with an adequately equipped laboratory, presenting a lesson on "chemical reaction rates" to a highly motivated class with an adequate understanding of English and on the other hand an under-qualified and inexperienced teacher presenting the same lesson,in a school with an ill equipped laboratory to unmotivated pupils with a poor understanding of English.

There is an **Intended Curriculum** which is what teachers intend to teach their pupils, as well as an **Unintended Curriculum** which is what pupils acquire after selecting from what the teacher says as well as from their own experience. For example a teacher may intend to teach science but in the process give away the fact that he comes from a privileged background. Some pupils may end up getting the impression that you have to come from a privileged background to learn science successfully.

The **Hidden Curriculum** refers to the unstated rules of a particular school or culture (Buckland 1982, Giroux and Penna, 1988). Indeed "some people argue that the hidden curriculum is actually more important than the formal curriculum."(Sached, 1986) Giroux (1983, 61) even argues that "the concept will have to occupy a central rather than a marginal role in the development of curriculum theory". According to Giroux (op-cit, 44):-

> ..a more viable approach for developing a theory of classroom practice will have to be based on a theoretical foundation that acknowledges the dialectical interplay of social interest, political power and economic power on the one hand, and school knowledge and practices on the other.

Further, citing Apple and King (1971), Giroux (op-cit, 59) says that "the hidden curriculum of schooling encompassed and reproduced a whole range of meanings that represent selections from the ideological and cultural resources of dominant interest groups" and hence in this context; "...notions of conflict and resistance are either ignored or assigned a negative role" (Apple, 1971 in Giroux ibid) for this reason "schools were now seen as political institutions, inextricably linked to issues of power and control in the dominant society."(Giroux, op-cit, 45)

Buckland (1982), argues that a serious attempt at curriculum development has to address all these ramifications of the concept "curriculum". The very notion of considering curriculum to be a selection from the culture focuses on the choices that are made in curriculum design and development. The implication of this is that any attempt at curriculum evaluation has to bear the particular selection from culture in mind. It is practical and political interests as well as a perception of science that determines the selection from culture made by the curriculum developers, in the context of curriculum design and development (Schubert,1986). On the other hand, in the context of a given official curriculum, it is teachers perceptions of science,as well as their practical and political interests that are partly responsible for the received curriculum (Schwab,1969;Schubert,1986).

The definition of curriculum as a selection from culture has been invoked on the one hand. On the other hand the situation-specific interactions that take place between the teacher,learner subject-matter and milieu has been considered. (Schwab,1969) A synthesis of these two perspectives results in an **interactionist** rather than an **absolutist** perspective of curriculum in which we see curriculum as a **process** rather than as a **product** or a **fact**. To put it differently interactionism means that it does not make sense to speak of a curriculum independently of the interactions that take place. The interactionist problem in the social sciences is akin to "Heisenberg's Uncertainty Principle" (New Scientist; 1992 133 ;1808, 36-40) in the physical sciences. According to Heisenberg's principle we cannot determine the value of the position and momentum of a subatomic particle with unlimited accuracy.This occurs because attempting to measure a value of the position changes the momentum, while attempting to measure the value of the momentum changes the position. For this reason there is always an uncertainty about the position and momentum of a subatomic particle. One interpretation of this principle is to view position and momentum as complementary interacting values rather than entities with an absolute magnitude. (Feyerabend 1991, 30, New Scientist ibid). In the same sense the received curriculum cannot be spelled out as a list of items, activities or facts but rather as tendencies that arise out of the interaction between the teacher, pupils and the official curriculum.

As suggested and argued earlier, such a selection from culture is partly determined by political and practical interests. Justice in making such a selection can be achieved in the same way that justice is achieved in political and practical matters:through "democracy". Democracy may be interpreted as acknowledging the fact that people do not have identical beliefs as well as the fact that beliefs often represent interests rather than truths.

The concept of democracy seems to be the guiding light for all political activities. The Concise Oxford Dictionary (1976) defines democracy as " a government by all the people, direct or representative ; form of society ignoring hereditary class distinctions and tolerating minority views."

In the context of curriculum design, development and evaluation "democracy" is usually seen as accountability to stakeholders.(MacDonald 1974). Stakeholders are those affected by curriculum decision-making. Democratic decisions entail consulting the relevant stakeholders before they can be made. "Democracy" in curriculum matters as well as in all other political and practical matters is not a non-problematic concept to put it mildly. This arises partly because of the dialectical relationship between leading and being led. Leaders who want to be fair consult "the people" in order to act in their best interests. On the other hand "the people " do not necessarily have their own opinions, expertise or competence and may, in fact, be waiting to hear what their leaders have to say. For example the problem of what changes should be made to the present curriculum does arise in the analysis of the responses to questions on teachers' perceptions of science.

2.2 THEORETICAL PRINCIPLES FROM THE PHILOSOPHY OF SCIENCE

On the one hand, from a scientific point of view, curriculum decision-making at a national or regional level entails questions about what selection has to be made from a vast body of available scientific knowledge. On the other hand, from a political point of view the question of who makes the selection, for whom, by what criteria; is important. It therefore seems that such choices are determined not only by scientific knowledge itself, but also by political, cultural, economic and other relevant factors impinging on such choices. For example whenever debates on education arise the question of a need for "skilled manpower" surfaces. What usually follows from this is a call for more technical and technological education so that "this country can prosper economically." (this point is alluded to in Lawton, 1989) Making such choices entails deciding why we teach science at all. However the question of "why teach science" carries with it a presupposition which is usually tacitly assumed. That presupposition can be exposed by asking "What is science?".

The question "what is science" is a philosophical one. A good philosophical question seems to be one that does not have answers "a-priori". Saying there are no answers a-priori means that it is not possible to establish common **premises** from which we can reason deductively to find the answers. Debates in the philosophy of science seem to hinge around this issue as will hopefully be demonstrated shortly.

In the context of science curriculum development, deciding on what should be selected from a vast body of "scientific knowledge" therefore also necessarily entails deciding whether a given claim to "knowledge" is science, biology, religion, magic or superstition. Making such a decision takes us straight into the "demarcation problem" (Popper,1959)

The "demarcation problem" as presented by Popper (op-cit), positivists and other philosophers of science, (some people consider Popper himself to be a positivist of some description while others disagree. B F Nel points this out in the unpublished article "refractions on reality") has to do with separating "scientific knowledge" from "non scientific knowledge". There may be practical reasons for such a separation: for example institutions of learning demarcate disciplines for administrative reasons, libraries classify books and so on.

That such a demarcation is clearly problematic is evident from the debates in the literature on the philosophy of science (Popper, 1959; Kuhn,1962 Feyerabend 1988). On the one hand philosophers like Popper (op cit) and their followers hold that science can,in principle at least,be separated from non-science. On the other hand philosophers like Feyerabend (op cit) and their followers take a very dim view of this "so called demarcation problem" and contend that attempts at solving this "problem" represent the very dogmatism, superstition and irrationality which the rationalists condemn and despise.

It would seem that there are three ways (used by "laymen" rather than "philosophers") of deciding whether, a given claim to knowledge is scientific or not:

(a)They consider what it deals with; nature, human beings, animals and so on.

(b)They consider the method originally used in arriving at that knowledge claim; such as a discovery, creation of the imagination, "revelation" and so on.

(c)They consider ways in which it is sustained and transmitted; such as imposed by authority ,openly debated ,involves a leap of faith,practical investigations and so on.

Philosophers (as well as laymen) who contend that science can, (in principle at least), be separated from non-science hold that there exists a specific "scientific knowledge content", which is the product of applying a specific "scientific method", which we have to discover and/or follow if we intend to be "truly scientific". Those who eschew the "demarcation problem" hold that separating knowledge is purely for convenience and that there is no such thing as a unique "scientific method". This debate is not confined to "armchair philosophers" alone, and frequently surfaces overtly or covertly in debates on curriculum matters.

The thrust of Popper's argument in the "Logic of Scientific Discovery" (1959) is that:-

(a)We can only accept a given theory (view,model and so on) as "scientific" if it is testable (refutable).

(b)A scientific theory cannot be proved conclusively true by a given test (or attempt to refute it), but can only be considered as provisionally confirmed.

The thrust of Feyerabend's argument against Popper and other advocates of "scientific rationality" in "Against method" (1988) is that:-

(a) It is not possible to decide in absolute terms whether a given test for a theory is fair because of limitations in our knowledge.

(b) There does not exist a specific "scientific method" but several "methods" which cannot be captured in rational terms. Feyerabend (ibid) goes on to argue that as a corollary of this: any attempt to specify a particular kind of scientific rationality results in a contradiction; thereby tending to give the impression that science is irrational.

One manifestation of the philosophical dimension (with special reference to the "demarcation problem") is the tone in which authors on science tend to refer to past beliefs in science. In the first place science authors usually only mention past beliefs in passing, as a brief introductions to theories still in current use (say Newton's laws). The tone typically used is something like "people in the past **thought** that........Now we **know** that......" For example Coleman (1990, 14) uses that tone in discussing an unsuccessful attempt by Galileo (1564-1632) to measure the speed of light. (The argument presented here is that although Galileo guessed correctly that light has a finite speed, he could not possibly have measured this very high speed; given the margins of error of the method he was using) Coleman's intention in this case is to show the amount of scientific progress since the days of Galileo. However in the process he creates the impression that today's knowledge is **final**. (The distinction between the intended and unintended curriculum becomes particularly relevant in cases like these.) There seems to be no doubt that some of our present "scientific knowledge" will still be regarded as "knowledge" thousands of years from now, but it is most likely that most of it will be ridiculed in the most contemptuous terms possible!

Such dogmatic reference to present scientific knowledge misses the point of what knowledge really is about : a way of adapting to the environment.(Who is better adapted to his environment; a prehistoric "caveman" who knows how to make fire, has mastered all the tricks for surviving in his harsh environment, and is in full control of his life or the average modern city dweller, who relies on "experts" for just about all facets of living?) Further such ahistorical reference to past belief tends to cloud the real issues, take historical characters out of context and produce a caricature of the personalities involved. For example Gil-Perez and Carescosa in a (rather contemptuous) account of science in a preclassical era accuse Aristotle of using a "methodology of superficiality" (in referring to falling bodies) when he said that:

> "A given weight covers a distance in a given time, a bigger weight covers the same distance in less time....."(Gil-Perez and Carascosa 1990, 534)

(Someone with a knowledge of Newtonian Mechanics may be forgiven for believing that Aristotle was not a very bright fellow on reading this!) Given that using Newtonian Mechanics in this context normally involves **neglecting** air **friction**, other authors argue that such statements are unfair in that Aristotle

explicitly stated that he was dealing with a "real world" in which effects of friction could **not be neglected.** (Toulmin, 1961, 44-61;Feyerabend 1978, 53-65) Further, at present we make a clear distinction between concepts like weight and density which were not explicitly distinguished in the past. Now it is possible to argue that what Aristotle really meant was that a **more dense** body has a higher **terminal velocity** than a **less dense** body (if they have the same shape and all other relevant factors are equal).This makes perfect "scientific sense"! Toulmin (1961, 51) makes roughly the same point when he alludes to the relevance of Stokes law to Aristotelian mechanics. The intention here is not to that argue that Aristotle was a scientist in the modern sense of the word (!) but to raise a few questions. When we make statements like "Aristotle said......" as examples of "unscientific thinking" in the past, do we know what "Aristotle" meant? Do we know what problems he was addressing? Do we know the context in which he was working?

The philosophical dimension is also manifest in the notion of "scientific explanation" which is closely allied to the notion of a "scientific method". A "scientific explanation" seems to assume the existence of a "scientific method" and hence the possibility of demarcating science from non-science.

Focusing on the concept "scientific explanation" requires a clarification of the contexts in which an "explanation" is accepted. For the sake of space, clarity and in order to focus on the usefulness of this term and the "interests" served by a given "explanation" (Habermas 1972) (rather than the precise meaning of the term "scientific explanation"); no attempt will be made to engage in the arcane terminology and esoteric categories used by "experts on scientific explanation" (see Salmon, 1984). Instead a commonsense definition will be suggested. In order to be acceptable, in a given context, an explanation must:

(1) Make sense of observations

(2) Represent reality

For example rationalists may argue that "unscientific explanations," such as the causation of diseases by spirits may **make sense to "primitives"** but are nonetheless unacceptable because they do **not represent reality.** (The rationalists may argue for example that "spirits" cannot be detected by rational/empirical means and/or do not exist). Rationalists would probably concede that some esoteric "scientific explanations", such as the relation of gravity to space-time curvature, only **make sense to a few experts** but add that they are acceptable as the **closest representatives of reality** available. (They are said to possess verisimilitude). Now, short of taking a leap of faith in "experts" is it really possible (for a given person or group of people) to decide that something represents or does not represent reality if it does not make sense (to him/her/them)?

In an attempt to clarify the above arguments, this commonsense definition of "scientific explanation" is then located in the context of Stinner's paper on "The Teaching of Physics and the Contexts of inquiry from Aristotle to Einstein" (1989) in Science Education.

Stinner (op cit) considers the evolution of the "scientific explanation" for a freely falling body, in the context of prevailing beliefs. (The categories and basic "scientific explanations" have been taken from Stinner. The basic beliefs and contexts have also been taken from Stinner but fleshed out differently by the author)

(a) To Aristotle and his followers free-fall was natural and non-problematic. Their explanation, if asked, would possibly have been "what goes up must come down". This is a commonsense view that is probably still held by most people. (Things certainly do not fall up!) This view is perfectly adequate for nearly all practical purposes. Even "hard scientists" like chemists do not really need a more sophisticated explanation or theory in their work. In a sense this commonsense view **makes sense** of **observations** and **represents reality**.

(b) To Newton and his followers free fall was not natural. It was seen as "caused by mutual gravitational attraction between the Earth and any other bodies with mass". A question may arise as to why another explanation is needed if Aristotle's commonsense view was (and for nearly all people probably still is) adequate.

As pointed out in the second chapter, there is no real consensus about how scientific theories come about (contrary to rationalist rhetoric). It is hard to say how Newton arrived at his theories. However it is possible to locate them in an historical context.

Newton (1642-1727) lived in the seventeenth century. The famous voyages of discovery by Vasco Da Gama, Christopher Columbus and others had already taken place. There was a general awareness, among Western intellectuals at least, that the world was round. In such a round world "up" and "down" are categories that do not make sense. (Is someone in China above or below someone in America?). Newton's explanation is therefore necessary for **intellectual satisfaction** in this context. In a post-Newtonian world "up" and "down" are not seen as absolute but as determined by the surface of the Earth and the direction of the Earth's gravitational attraction. Newton's theory of gravitational attraction also had a broader Astronomical impact which will not be discussed in this context.

Is Newton's explanation really **useful** in an everyday sense? It is; if you are working in the space programme and need to calculate variations in gravitational attraction as a space probe traverses interplanetary space on travelling say from Earth to Mars. (Scientifically minded people may argue that engineers routinely use Newton's laws of gravitation in their calculations. They may use them in the form $f=mg$ where g is a **constant** with a value $9.8m/s^2$ and certainly not the full rigour of $f=GMm/r^2=mg$ where g is a **variable** depending on distance from the centre of the Earth. It can be argued that only engineers involved in the space programme do this). Does Newton's explanation **make sense of observations**? Yes, if you have seen photographs of the round Earth taken from a space probe (which would remove all reasonable doubt about whether the earth is flat or round, and thus require justification for the fact that thing fall "down" towards the Earth). Does Newton's explanation **represent reality**? Well, whose reality? The reality of the "sophisticates" who suspended all their activities to watch the first manned Lunar landing on T V, who have books and magazines with colour photographs of the Martian and Lunar landscapes taken from space probes, as well as details about the Martian atmosphere, Martian climate and Martian gravitation? What about the reality of those who went about with their business as usual during the first manned lunar landing, do not have T V, do not read newspapers, have not seen photographs of anything taken from space probes, wonder why scientists and engineers bother with space exploration when there are enough unsolved problems on terra firma?

(c)To Einstein (1878-1955) and his followers free-fall was seen as natural and not caused by a force. The "scientific explanation" is that "what appears as gravitational attraction is in reality a natural manifestation of space-time warps in N-dimensional curved space-time". (Einstein originally proposed four dimensions. Supersymmetry and superstring theorists in their search for "the theory of everything" have proposed 26 ,11 and 10 dimensions according to F D Peat 1988. There seems to be no consensus at present about the exact number of dimensions, hence the general term N). Einstein's followers; that is those with a complete grasp of the meaning and significance of his theories, are specialists in Applied Mathematics and Theoretical Physics. (Einstein argues that the perceived effect of the **force of gravitational attraction** on a body moving with **constant velocity** in **linear** Euclidean space, is indistinguishable from perceived effect of **angular acceleration** as a body moves with **constant speed** in **curved** non-Euclidean space. Hence the effects of either gravitation or acceleration on a given mass are equivalent. In technical terms it is not possible to distinguish the **inertial mass** from the **gravitational mass**. This argument is used as one of the cornerstones in developing the general theory of relativity according to Coleman 1990, and Peat 1988). Some of the basic premises of Einstein's theories (Stinner 1989) are that:

(1) The speed of light (and other forms of electromagnetic radiation) is constant irrespective of frame of reference.
(2) Interactions (coulombic, electromagnetic, gravitational) are not instantaneous but limited by the speed of light.
(3) Space is non-Euclidean.
(4) Time is not absolute.

Is Einstein's "explanation" **useful** in the everyday sense? Well...not yet. Does this explanation **make sense of observations**? Well, it depends on what you mean by "observations". If you are a specialist and can interpret highly complicated numbers, graphs and so on emanating from scientific apparatus which are used to monitor certain effects in interstellar space....yes. Does it

represent reality? Well...,what do you mean by "reality"? Einstein's theories are certainly not about "commonsense reality".("Curved space" and "time-dilation" are not the stuff "commonsense reality" is made of.) In any case discussion of research on black holes, twistors and superstrings, which attempts to extend General Relativity, is incomprehensible to someone who has not specialised in General Relativity and/or Elementary Particle Physics, except in a very diluted and possibly distorted form. In addition the most advanced theories in Physics are accepted for aesthetic reasons and mathematical consistency, without being tested in the experimental sense partly because equipment to test them may take decades to develop (Peat 1988). In this context Peat (op cit) argues that whereas in the past theoretical physicists and experimental physicists were usually the same people, nowadays there is a growing gap between the two groups. This flies in the face of the image of science as an experimental practice.

Clearly, even a simple "phenomenon" like free-fall raises problems about what is "natural", what is "caused", and indeed what the nature of a "scientific explanation" is. It therefore seems that calls for "scientific explanations" ,"scientific attitude " and so on may call for qualification or justification. Otherwise such calls may be mere rhetoric rooted in dogma. In reality appeals for "scientific explanations" are made in a context where some people are seen as having misconceptions and beliefs which have long been superseded by science. (Some examples quoted in Feyerabend ,1988,1990 are Astrology, Raindancing, and Faith-healing. In this country examples of African traditional medicine as well as practices linked with African traditional religion may be cited). Habermas (1972) argues that "knowledge" serves specific human interests. This argument may raise problems about the extent to which, for most people, being "scientific" really means accepting the views of "experts" who speak in jargon that they do not understand, who may well have interests and concerns that they do not share. This argument applies both to non-scientists as well as scientists, when they need to form opinions outside their fields of competence. Even "experts" frequently disagree strongly on many issues centred in their purported fields of competence. Anyone who reads professional journals on a regular basis would probably attest to this. The debate between Lythcott and Duschl (1990) versus Lawson (1988,1991) about the way in which the principle of Constructivism should be interpreted, in Science Education is a classic example. Feyerabend (1988) argues that even a consensus of "expert opinion" may arise from shared prejudices and misconceptions and thus need not always be taken seriously.

The preceding discussion raises further questions. The main concern in the "philosophical dimension" is with the following questions:-

(a) How dogmatic is the science presented in the Official Curriculum?

(b) Do teachers have any perception of this "dogmatic presentation" of science or do they simply take it at face value? (c)What effect does this "dogmatic presentation", its perception or lack of it have on the teaching practise of teachers?

Some questions of general interest,which will not be pursued except tangentially, may be the following:-

(a)How many times are views from the past as well as from present day "primitive cultures", dismissed as "unscientific", by "learned intellectuals" without adequate evidence being supplied to support the statements being made? (b)Is science really progressive in that it gives us more and more "fundamental truths" about nature or is this "progress" one of the "great illusions "of the "scientific era"?

Views of authors like Feyerabend and Kuhn in this regard are beginning to have an impact in debates about curriculum decision-making in countries like the United States.Such views may need to be considered in this country as well.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 THEORETICAL BASIS OF THE STUDY

This study does not attempt to test a specific hypothesis but attempts to generate some of the issues which may be important for future curriculum development in this country, with specific reference to Physical Science . In generating such issues it is hoped to raise specific problems in which further research may be done, as well as some issues which curriculum developers in other fields can address. Such an exercise may also help in identifying areas in which there might be a need to conduct in service courses in order to address teachers' subject competence as well as raise their consciousness about relevant issues in science curriculum decision-making.

In chapter two it has been argued that viewing curriculum as a "selection from the culture" (Lawton 1983), in the context of an interpretation of curriculum as "commonplaces of teacher, learner, subject matter and milieu" (Schwab 1970) entails a model of curriculum as a process rather than a product or fact. The assumption being made in this study, that teachers' perceptions of science are revealed both by what they **say** (about science) as well as what they **do** in their lessons, is in line with the view of curriculum as a process; because it goes beyond the syllabus. Hence the link between teachers' perceptions of science and the received curriculum is viewed as logical rather than empirical; in the context of curriculum viewed as a process.

3.1.1 <u>RATIONALE FOR THE METHODOLOGY USED</u>

Research methodology employed in this study is generative (Simon 1986) rather than experimental. Nonetheless there is due recognition of the existence of variables such as qualification and experience. These variables are not "controlled" in the experimental sense but are noted because they may help in interpreting teachers' responses. The methodology used is generative in that an attempt is made to get a picture of the concerns and issues that is as complete as possible from the responses of all the teachers involved. This is in line with the notion of giving teachers a say in the curriculum (in line with the notion of democratising curriculum decision-making mentioned in chapter two). In this context the basic principle is that there are no "correct" or "wrong" approaches to curriculum design ,development and evaluation but merely theoretical positions which are not <u>a priori</u> defensible. (in the same sense as mentioned in chapter 2 page 7).

Teachers are taken to be central figures in curriculum development and not as mere agents who should implement what experts recommend. This study is premised on the notion that teachers' perceptions of science are important factors to be considered .It is argued that they are not mere impediments which may not be congruent with those of the experts. A further premise is that teachers' perceptions of science should be one of the determinants of the Official Curriculum (as well as the Received Curriculum) if teachers are not to be alienated from the very task of teaching (that is if they are to teach something that has any meaning to them at all).

The research methods used in this study are interviews, classroom observations and content analysis of relevant documents. Interviews and classroom observations are used in investigating teachers' perceptions of science, whereas content analysis is used in investigating the presentation of science in the official curriculum. However, greater emphasis is given to teachers' perceptions of science with the Official Curriculum ,as found in syllabus documents and work programs, serving to reveal the official view of the kind of science pupils are supposed to learn at school. Further, questions posed to the teachers centre not only around perceptions of science in general, but also around perceptions of the kind of science that is supposed to be taught in the Official Curriculum in particular.

Hence methodology used in this study is referred to as "multiple operationism" (Simon 1986,12) because "researchers use a variety of methods of investigation (interviews, class visits and content analysis) that are related to each other" (Burgess 1984 ,143) "as mutual checks upon one another" (Simon 1986,13). Burgess (1984,143) raises the questions:

> ..how far does the researcher's presence influence the generation of data? (internal validity). Can the data that are obtained in studying one situation be generalised to other situations? (external validity)

The strategy of multiple operationism is an attempt to address these concerns, particularly in the case of "internal validity". The underlying assumption behind multiple operationism seems to be that results can be regarded as valid if **different** methods yield the **same** results. It is worth noting that an epistemological objection can be raised to this notion of "**validity**". The Concise Oxford Dictionary (1976) defines "valid" as "sound, defensible ,well grounded". A belief that is "well grounded" and based on a method that is "sound and defensible", according to a **given tradition** (the tradition observed by given researchers), is clearly not **necessarily** a reflection of **objective reality**, but may be viewed as one perception of reality amongst many. Indeed, such a belief may in fact be considered to be a falsehood based on a method that is **invalid** according to **another tradition** (the tradition observed by the target group, other researchers and so on). This represents the same type of limitation to our knowledge as that mentioned in chapter two when the question of a "scientific method" was raised (page 9). It seems that debates about the validity of a given method can only be conducted if the participants are prepared to recognise a given tradition or traditions. Walizer and Weiner(1974, 407) make the same point when they argue that:-

> Determining validity requires an assessment of the link or match between a **conceptual definition** and an **operational definition**.(and that)....whatever procedure we use to assess validity ,ultimately we have to rely on judgement ...(because)... there is no

> direct way to assess the validity of a measure.(and further that) ..holding together every procedure to assess the validity of indicators is judgement.(the author's emphasis)

"Conceptual definition" refers to the way in which a relevant concept is defined and /or commonly understood. (Walizer and Weiner op-cit, 36) The central concepts of "perceptions of science", Official Curriculum and "received curriculum" have already been defined in chapter two. "An operational definition is a complete set of instructions for what to observe and how to measure a variable" (Walizer and Weiner op cit, 36) in identifying the concepts being studied. In this context the focus is on what teachers say, what they do as well as what official documents and prescribed books require. These factors are then used in identifying teachers' perceptions of science and the requirements of the Official Curriculum.

Walizer and Weiner (op cit) effectively argue that scientists are socialized into accepting specific standards of assessing validity when they say that:-

> When a member of the scientific community moves into a new area of research, typically a great deal of time will be spent examining previous measurement and consulting experts in the field to become familiar with how important concepts might be measured. (and that) the process of validation is one of shared judgement and openly communicated procedures of measurement.

The main concern with internal validity,in this study is centred on whether the methods used reveal what they purport to reveal subject to the conditions stipulated above. Even when a study has internal validity it does not follow that the results can be generalised to another similar situation, a necessary condition for external validity. The question of external validity may be an empirical one that can be addressed by studying the "other situations" using methods having "internal validity", in cases where external validity does not follow from internal validity a priori. It can be argued that in Psychological studies such as Piaget's study of "developmental stages" we can generalise from a study based on a small sample because "development" in this case is a function of certain known variables. In Curriculum studies ,authors like Schwab (1970) have argued that curriculum problems are "situation specific"; thus pointing out the dangers of generalising from a given study. Only one "situation "is addressed in this study hence the problem of "external validity" as defined by Burgess (op-cit) need not be addressed.

The strategy employed in identifying teachers' perceptions of science is based on the above assumption. Hence it entails finding out what they say about it (in the context of an interview as well as in other relevant situations) as well as the teaching methods they use in class. The methodology of this investigation therefore consists of interviews and classroom observation; with classroom observation serving to reinforce and/or confirm the interview data. An attempt is made to raise issues for comment by the teachers rather than purely yes/no, or true /false responses. As a result informal as well as open-ended interviews are used (Simon, 1986). For this reason teachers do not give answers to specific issues, but raise issues within specific themes such as the issue of teacher consultation in curriculum development. Although the themes to be addressed have been alluded to in the first chapter, there is a need to generate the themes by means of informal interviews. This helps not only in generating fresh themes that had not been thought of before, but also in adding focus to the unstructured interview questions. Adding focus to these questions then helps in fleshing out themes that had already been identified as well as those generated during the informal interview phase.

3.1.2 INFORMAL INTERVIEWS

According to Simon(1986,36):

> Denzin (1970,126) technically terms informal interviewing as nonstandardized interviewing where no pre-specified set of questions is employed, nor are there questions asked in a specified order.
>
> There is no real interview schedule employed in this instance.Questions are asked in any order as the interviewer probes relevant issues which are raised in the course of the interview.

3.1.3 SCHEDULE INTERVIEWS

This phase of the research represents the "fleshing" out of themes using open-ended interview schedules where respondents are asked to provide open-ended comments on each of the themes (Simon 1986, 15).

3.1.4 CLASSROOM OBSERVATION

The purpose of classroom observation in the context of this study is to corroborate teachers stated perceptions of science by finding out what they do in class. Teachers perceptions of science, as informed by what they do in class, are revealed in the teaching methods materials and teaching aids they use. This is subject to restrictions, such as availability of specific types of teaching aids in given schools. Further, time constraints as well as prescriptions by the department, circuit or the given school may also be limiting factors in determining the way in which teachers present their lessons. For this reason there seem to be limits to the extent to which teachers' perceptions of science determine the Received Curriculum.

3.1.5 CONTENT ANALYSIS

In chapter two the question of whether the Official Curriculum presented a dogmatic image of science or not was considered. The question of how this Official Curriculum is perceived by teachers was also considered. The Official Curriculum is represented by the relevant syllabus or syllabi, prescribed books and work programmes as mentioned in chapter two. Hence there is also a need to analyse the message or messages contained in these documents and to relate this to teachers' perceptions of science.

This entails employing a strategy called content analysis. Crano and Brewer (1973:197 in Simon, op cit, 32) define a "content analyst" as someone who "is concerned with the particular content of a message,and the particular manner in which this message is expressed." According to Pool (1959;27 in Simon op cit, 32) The content analyst must also consider "the **purpose or objective**" of the communication, its context (which includes related events preceding or accompanying it), time and place.

A content analysis of relevant books and syllabus documents is also undertaken with a view to identifying and revealing certain consistent themes. The themes to be identified relate to the notion of science as well as the notion of the Official Curriculum as discussed in chapter two. Teachers' perceptions of science are then compared with the views of science as depicted in the Official Curriculum documents. The relationships and contrasts between the Official Curriculum and teachers' perceptions of science will then, hopefully, be brought to light.

3.2 PRACTICAL CONDUCT OF THE STUDY

3.2.1 SAMPLING

Since there were only fifteen schools offering Physical Science up to standard ten in Umlazi in 1992 (that is 15 schools in Umlazi North and South combined) a decision to involve all the schools (a census) was initially made. The order in which the study was conducted was random (that is, schools were not taken in any specific order)

In practice eleven of these fifteen schools offering senior Physical Science in Umlazi were visited. Some schools in the Umlazi South circuit were not visited because trial examinations in September and Examinations in the second week of October meant that class visits could not be conducted. Fifteen teachers in the eleven schools were visited because four of these schools had two senior science teachers and a decision to interview both was taken in these cases. Fifteen interviews and fourteen class visits were conducted because one of the teachers, who was a deputy principal, got taken up by administrative duties on the day scheduled for a class visit and another class visit could not be scheduled. Selection of teachers for informal interviews and schedule interviews was entirely random.

3.2.2 GAINING ENTRY

The fact that the researcher is a Physical Science subject advisor in KwaZulu schools, and that the target population consisted of some of the Physical Science teachers in KwaZulu, helped in solving the problem of gaining entry (Simon 1986,40;Burgess 1984,31). If an outsider had intended to do research in KwaZulu schools this might have entailed a lengthy (and possibly unsuccessful) negotiation with the department.
The first step in seeking entry was to get permission from the circuit inspectors in charge of the Umlazi North and Umlazi South

circuit offices. Letters were written to the circuit inspectors explaining the nature and purpose of the research. In addition meetings were held with both relevant circuit inspectors. They both granted (verbal) permission. Written permission was not insisted on since further problems could not be foreseen.

Relevant principals and teachers were then approached, and the nature and purpose of the research explained. Appointments were then made for interviews and class visits. No problems were encountered in getting the consent of the principals. In most cases they were delighted to get a visit from a subject advisor, although an attempt was made to explain to them that the present role was more as a researcher than an advisor.

The explicit consent of all the 15 teachers interviewed was obtained, with some being delighted to get a visit from an interested person. However one teacher seemed somewhat uneasy and intimidated (probably by the fact that the person doing the research was a subject advisor) while another expressed some dislike for participating in social research but agreed to be interviewed all the same. (This is possibly an example of "Black hostility towards field investigators" mentioned by Simon, 1986. This hostility is hardly surprising:in this country ,with its history of racial discrimination, there have been many ostensibly scientific sociological studies which are viewed as "racist" by Blacks. The fact that the person conducting the research was also Black does not mean that he cannot be employed to do the "dirty work of the regime." As a possible further example of this, Another teacher in refusing to be taped explicitly stated that he could not accept any assurances that the tapes were for the consumption of the researcher only.)

Further, the extent to which the role of the researcher as a researcher was confused with his role as an advisor may have proved to be problematic in some cases. This occurred because some teachers may have seen the researcher more as a departmental official than as a mere researcher, in spite of reassurances that were given. For this reason they may not have been as candid as they could have been. There is no tangible evidence for this in most cases. Two teachers were visibly concerned about giving acceptable answers. One of these kept asking if the answers he gave were correct in spite of repeated assurances that there were no "correct or wrong" answers but merely views which had to be considered.

It is possible that more reliable information might have been obtained if one school was selected for a case study, instead of a census of all the schools. For one thing there would have been more time to win over the confidence of the relevant teachers.The researcher might have managed to get the teachers to see him as an insider,genuinely interested in the affairs of the school, not as an outsider, who merely wants information for personal gain. This would have gone a long way towards solving the problem of entry.Further, more instances of the relevant teachers' perceptions of science might have been studied.However a trade off arising from this approach would have been loss of variety as well as ability to generalise.

3.2.3 INFORMAL INTERVIEWS

Questions were posed to teachers to investigate their general concerns and attitudes. These questions were not asked in any specific order. An attempt was made to raise and probe issues in the context of perceptions of science as outlined in the first chapter. Informal interviews were conducted among 8 teachers with notes being taken. A tape recorder was available but none of the teachers agreed to be taped. (The teachers did not give any specific reasons for refusing to be taped. They merely expressed a general discomfort with the idea .The researcher felt that it would be improper to force issues as this could antagonise the teachers.) In each case the notes were read back to the teacher to find out if s/he agreed with what was written down, with appropriate changes being made until the teacher was satisfied that the data taken down was an accurate reflection of her/his views. It is probable that if a tape had been used more reliable data could have been obtained. The initial intention was to generate some philosophical themes relating to teachers' perceptions of science and of science education as practised in this country. These themes would then have been used in the construction of an interview schedule.

3.2.4 SCHEDULE INTERVIEWS

No specific issues relating to fundamental principles in science and science education were generated during the informal interview phase. The interview schedule then consisted of more or less the same type of questions that were asked during the informal interview phase but arranged in a consistent fashion. This helped in getting teachers (particularly the less outspoken one) to say more about issues like the nature of science and what they would like to see in a new curriculum. Nonetheless, as will be discussed under result analysis, fundamental issues about the nature of science and science education were still not raised.

Schedule interviews were conducted among 7 teachers.The 7 teachers involved in the schedule interviews did not include any of the 8 teachers involved in the informal interviews. Although administering the informal interviews as well as the schedule interviews to all teachers involved in this study might have been an advantage, it would not have been a great advantage. As will be shown in the analysis of results, most teachers raised more or less the same issues during interviews.The teachers seem not to have done much reflection about the fundamental nature and purpose of science education as had been hoped. Further,it did not seem necessary to interview the same teachers twice, given the limited scope of the study and the fact that most of the questions were repeated, although in a more orderly and focused manner.

This fact does not seem to pose any specific methodological problems. In an example cited by Simon (1986 18) in his study of ex-Zimbabwians, the people used in generating themes are not necessarily the same as those used in fleshing them out.All we know is that they belong to the same target population as ex Zimbabwians.(Social science research would not be possible without a presumed similarity in views,behaviour and so on of people in a given target population) .

In this case a tape recorder was still available and the option of being taped was mentioned to the teachers. Again none of the teachers agreed to be taped. Six teachers did not give specific reasons but merely expressed general discomfort with the idea. They were not pressurised into giving reasons but merely reassured that the tapes were for the consumption of the researcher only. One teacher explicitly stated that he could not accept any assurances that the tapes were for the consumption of the researcher only. (This particular teacher expressed a concern that the tapes may be played to others in a context in which he would be made to appear foolish). Notes were taken from the teacher's responses.(In the same manner as described for unstructured interviews.The same comments apply.) This presented a difficulty in that immediate decisions had to be made about what was worth noting.

3.2.5 CLASSROOM OBSERVATION

As stated earlier this research also involved classroom observations.The main focus of the classroom observation was on the teaching methods,materials and teaching aids used by the teachers.Further,in some cases this involved looking at pupils' written work and the assignments given by the teachers. Questions were posed to the pupils in class where necessary (although this rarely happened). Posing questions to the pupils enabled getting an idea about their understanding of science vis a vis the teachers' methods within the context of local constraints. Lessons were discussed with the teachers after they ended. Where possible more than one class by the same teacher was observed. However this only occurred in three cases. An attempt was then made to synthesize the views expressed during this discussion with teachers' stated views about the nature of science.

3.2.6 CONTENT ANALYSIS

It should be noted that this study took place in 1992, and is based on a curriculum that was implemented before major reforms such as the ending of apartheid, unbanning of "liberation movements" such as the A N C were set in action. (The curriculum motion for a "new South Africa is presently (in 1993) in the melting pot) Given the context in which the Official Curriculum under investigation was designed ,developed and implemented, it can, without reasonable controversy, be described as; "A blueprint for science education under apartheid in South Africa."

3.2.7 TIME-SCALE AND SEQUENCING OF FIELDWORK

The fieldwork was undertaken between August 10 and October 15 1992. A total of 14 class visits and 15 interviews were made during these days.The interviews lasted between 30 minutes and

1 hour.

Five class visits were made in the normal course of duties of the subject advisor concerned. This is probably not problematic in that the work of a subject advisor also entails identifying the teaching methods used by teachers in class,which is part of the purpose of this research. All of these class visits took place in August. After these class visits interviews were conducted in two of the cases and appointments were made for later dates in three other cases owing to time constraints. In these three cases mentioned the interviews were conducted within a week of the class visits.

Nine of the class visits took place as part of the study, that is reports did not have to be written to anyone in the department about these class visits (reports are periodically written and submitted to the department for work done in the in the normal course of duties). Five of these took place in September and four in October.In seven cases class visits and interviews took place on the same day and in two cases they occurred within a week of each other.

3.2.8: SOME LIMITATIONS OF THE STUDY

The questions posed to the teachers assume that they are free to answer correctly. This is one of the central problems in social science research; human beings are capable of deceiving those trying to do research,particularly in issues related to belief and behaviour. If a case study were conducted instead of one off interviews ,it is possible that the confidence of the teachers might have been gained resulting in more reliable data. Further, as will be discussed more fully in the chapter on result analysis, it is difficult to draw conclusions from one class visit. However in doing a case study, the reliability and validity gained is traded off against the loss of variety.

In chapter two it was argued that the field of curriculum is political and hence requires democratic decision-making. This study is about identifying some of the issues that need to be considered in curriculum decision-making. In this case getting a reasonable number of stakeholders in generating issues has to be weighed against the reliability and validity gained in the close study of a few cases.

CHAPTER 4

4.1:ANALYSIS OF RESULTS

In the first chapter it is pointed out that partly as a result of educational policies pursued in the past, Black schools are short of resources such as books laboratories and equipment. The question of whether teachers in these schools are basically in agreement with the present curriculum, barring the provision of the relevant necessities mentioned is raised. Getting an answer to this question entails finding out if the present curriculum involves a "selection from the culture" (Lawton, 1983) which satisfies teachers' expectations.

An important question in this regard is the one of how the teachers who were interviewed came to specialize in science from high school level to tertiary level (college or university) in the first place. This is so because the reasons given for opting to specialize in science, given a choice, offer pointers to the way in which science was initially perceived by the teachers. For example, one person may pursue science because s/he thinks that it answers certain fundamental questions, whereas another may only be interested in the employment prospects open to someone with a training in science. A possible consequence of holding either of these two attitudes is that while the former may be expected to seek knowledge and understanding, the latter would probably only be interested in getting an acceptable pass mark (as well as the knowledge required by prospective employers).

In chapter 3 it is stated that notes were taken from teachers responses to questions posed. A record of classroom observations was also made. Tables were drawn in an attempt to interpret and group teachers' responses.

4.1.1:REASONS GIVEN FOR OPTING FOR SCIENCE

The reasons given by the teachers for opting for science are summarised in table 1 below:

TABLE 1

REASON FOR CHOOSING SCIENCE	NUMBER OF TEACHERS
(1) Peer group influence	1
(2) Career opportunities	7
(3) Skilful teaching	4
(4) Interest in science	7
(5) Selected for aptitude	4
(6) Parental influence	1

Among the reasons given by the different teachers were the following:-

(a) Peer group influence. The teacher concerned was encouraged to take science by his friends (one teacher)

(b) A basic interest in science. (seven teachers)

(c) Skilful teaching; resulting in good performance and development of interest. (four teachers)

(d) Career opportunities available to someone with a science related qualification. For example some teachers wanted to study medicine and other science related courses. They then came into teaching as an afterthought having failed to acquire places in medical schools as well as other science related institutions such as schools of engineering. (seven teachers)

(e) An aptitude for science. This was identified through good classroom performance in general science as well as aptitude tests. (Three teachers cited aptitude with one stating that he was selected for the science class after an aptitude test among other reasons)

(f) Parental influence. The teacher's parents encouraged him to do science in standard 6. They argued that science opens doors to many careers such as medicine. (one teacher)

Some teachers gave several reasons which collectively led to their specialising in science. As can be seen above, the reasons cited most frequently were "basic interest in science" (seven teachers) and "career opportunities" (seven teachers) available to someone with high school science. On the basis of the reasons cited most frequently, it may be expected that school science as a vehicle to science related careers should feature strongly in teachers stated perceptions of science. This dimension may be reflected in their perceptions of possible improvements to the present curriculum.

In this context the extent to which teachers would propose **fundamental changes** given a chance or merely **changes of detail** within the same basic philosophy as the Official Curriculum becomes crucial. It may be expected that if teachers are fundamentally dissatisfied with the science they are expected to teach, they would propose sweeping changes to the way which science is presented by the Official Curriculum.

The initial perception of science as pupils may be changed by experience as time goes on. However it is important for two reasons. Firstly, this initial perception may have helped in originally determining decisions by the science teachers to pursue studies in science as pointed out above. Secondly, the teachers' original perceptions of science were at least partly determined by the received curriculum **while they were still pupils**, we realise that such perceptions may not only offer pointers to this received curriculum but may help in regenerating it.

4.1.2: TEACHER PERCEPTIONS OF POSSIBLE IMPROVEMENT TO THE SCIENCE CURRICULUM

Table 2 shows the changes that were proposed by the teachers interviewed.

TABLE 2

PERCEIVED POSSIBLE IMPROVEMENT	NUMBER OF TEACHERS
(1) background knowledge for tertiary education	4
(2) Improvement to the logical sequence of topics presented	5
(3)Shifting to lower levels and /or exclusion of non-examinable sections	3
(4) Syllabus for a practical, concrete everyday approach to science.	3
(5) Better preparation for work in industry	4
(6) Treatment of topics relevant to the South African context	1
&p(7) Basically satisfied with the syllabus. Problems seen as emanating entirely from paucity of resources	2

Teachers suggested changes in the following areas of the science curriculum:-

(a) Changes should be introduced to give more background knowledge for further studies in science. (four teachers)(Tertiary studies in science and technology)

(b) Changes to the sequence and arrangement of the subject matter. There are, in the words of one teacher "gaps in the logical sequence of the science presented". The concern was with the concept development of the subject as well as getting and maintaining pupil interest.(Five teachers)

(c) Some teachers argued for the shifting to lower levels within the school and/or exclusion of non-examinable sections in the standard 9 syllabus. The concern in this case was with getting better results in the standard 10 examination, particularly in the context of Black schools always doing badly in this examination (3 teachers). The standard 10 examination was based on the standard 9 and 10 syllabi. All the work in the standard 10 syllabus was examinable. The teachers hoped to be able to spend more time on examinable sections of the work if non-examinable sections were shifted from the standard 9 syllabus, thus enabling the pupils to get better results.

(d) Syllabus seen as abstract. Argument for emphasis on concrete items from the everyday life experience of pupils. This was seen as facilitating understanding of scientific concepts by pupils and hence developing their interest in science.(3 teachers)

(e) Arguments for the treatment of topics with an industrial application including the active participation of industry in education. In this case schooling was seen as preparation for the world of work.(4 teachers)

(f) An argument for a treatment of topics relevant to the South African context was made. In this context the topic on radioactivity was deemed irrelevant by one teacher. (The irrelevance of radioactivity is debatable. It is not a good example of "irrelevant topics", given the existence of radiation therapy in hospitals, Koeberg nuclear power station and so on. However this issue was not raised with the teacher for fear of seeming to impose a view)

(g) Two teachers had no complaint about the content ,sequence and logic in the present curriculum but seemed to view problems in teaching and learning as emanating entirely from the paucity of resources.

The above discussion is about modifications to the official curriculum that were suggested by the teachers. However it should be pointed out that some teachers suggested modifications that addressed more than one concern. (see table 2 above) It is noteworthy that thirteen teachers favoured having modifications to the present Official Curriculum. The teachers proposed changes to the sequence and method of presentation and inclusion of more items; in order to accommodate topics done at tertiary level or those having an industrial application. However they did not explicitly favour exclusion of other items (except for the non-examinable topics mentioned in (c)) to make space in the school time-table for the extra items suggested. One teacher justified this anomaly by arguing that more work can be done in the same amount of time if the work is presented more systematically via an improved syllabus. He further argued that efficient time-management on the part of the teachers would also help. In this context another teacher hinted at a belief that departments for other races have teaching strategies and materials which are not available to departments for Blacks. He seemed to think that this would enable teachers and pupils to cope with extra work in the time available. His exact words were "I cannot say what can be excluded;I need exposure to materials in other (White, Indian and Coloured) departments."

The reluctance of teachers to suggest exclusion of some topics may be interpreted as a concern with possibly lowering standards by excluding too much, when compared with other departments. In this context one teacher explicitly mentioned the need to maintain a common "core syllabus". (When this study was conducted all departments had a common core syllabus. Schools in different regions could select options that suited them. However there is an awareness (frequently explicitly expressed) among KwaZulu teachers that schools in departments such as the Natal Education Department are in a better position to select more options because of access to superior resources and suitably qualified teachers.) Such a concern with "standards" arose particularly with the introduction of Bantu Education (in 1953) in which Verwoerd explicitly stated that "Natives" should not be given the same type of education as "Europeans" (Kallaway, 1986)

A possible concern that teachers may have is with the extent to which science is presented in a culturally biased way. In table

3 an attempt to analyse teachers' responses in this regard is made.

TABLE 3

VIEWS ABOUT SCIENCE PRACTISED IN BLACK CULTURES UNINFLUENCED BY WESTERN CIVILIZATION	NUMBER OF TEACHERS
"Science", of some description existed before western civilization. (A lot of this is mostly speculative and hesitant)	7
Not sure if science existed, would have to investigate	1
No articulated position	7

The table above reflects views of Black teachers interviewed about the existence of "science" of whatever description in Black cultures. Those who did have views on this matter were somewhat hesitant and lacked conviction.This may be a reflection of an argument raised in chapter 2 (25) that only modern (western) science is regarded as "knowledge". Other ways of thinking are dismissed as having no value even in their own context, being regarded as superseded by science. A possibility is that the teachers did not have any pool of knowledge, facts or standard arguments to draw on as all these are presented in the official curriculum as being on the side of science.

Teachers have suggested changes to the logic and sequence of topics presently in the official curriculum, as well as adding some topics; to make the curriculum more suitable for further study, as well as work in industry. These are all changes of detail which do not get to the roots of nature of science and science education as presented explicitly or implicitly in the official curriculum. The received notions of scientific method, objectivity and progress mentioned in chapter two, are not made problematic but merely embraced. Given that there was one interview session per teacher it is possible that failure to suggest fundamental changes to the present curriculum may have resulted partly from the fact that teachers did not have sufficient time to reflect on this issue. A more detailed study of fewer teachers may have revealed more in this regard. However what this study does show is that fundamental issues, such as questioning the notion of the scientific method and scientific progress **were not foremost** in the thinking of the teachers. This may be related to the kind of education that teachers themselves got as pupils.

As Penny Enslin (1984, 139-140) puts it :

> The Christian National Education Policy...as a whole...,including the sections specifically devoted to black education needs to be understood as a statement of those aspects of the dominant ideology which find expression in the apparatus of Bantu Education.

Further in her article, Enslin, (op cit) argues that Fundamental Pedagogics has replaced C N E as the theoretical rationale for education. Most Black teachers presently in the field have been exposed either to Bantu Education (implemented from 1953 onwards and directly influenced by C N E), or later developments and modifications of Bantu Education (as found in the so called "Department of Education and Training"), which have been influenced by fundamental pedagogics. (This accounts for just about all teachers trained in this country, who were below the age of fifty in 1992 when this study was conducted). Aside from the influences of Bantu Education or later modifications at high school level, most teachers in the schools visited got their training at colleges of education which use syllabi which have been laid down by the Department Of Education and Training (A mere change in name without changing the basic philosophy of Bantu Education. It seems that after 1976 the word "Bantu" was deemed to be impolite to the "Bantu" when used in an English or Afrikaans context and thus dropped from official documents. Actually the word "Bantu" in this context is a corruption of the words "abantu" in Nguni languages or "batho" in Sotho languages which mean "people" irrespective of colour or creed. However the words "abantu" or "batho" are seldom used in this all inclusive sense, even in African languages, owing to South African preoccupation with race). In this context Enslin (op cit, 145) argues that:

> Students of education are provided by means of the syllabuses, prescribed readings, and examinations in Fundamental Pedagogics with the ideology which suits the roles which they will have to fulfil as teachers, bureaucrats and professional ideologists.

Teacher acceptance of the notions of "scientific objectivity" and "scientific progress" is hardly surprising in this context.

Ideally perceptions of science should influence teaching practice and vice versa in a dialectical praxis. Such a praxis is only possible if teachers "reflect on their own practice" (Geddis, 1988), instead of merely passively transmitting knowledge. Do teachers reflect on their own practice? The analysis of stated views about the nature of scientific thinking as well as their classroom practices should throw some light in this regard. The assumption made in this study is that teachers' perceptions of science are revealed in both what they say about it as well as their lessons. A synthesis of stated perceptions of science as well as classroom observations should yield some interesting answers.

4.1.3: A SYNTHESIS OF STATED PERCEPTIONS AND CLASSROOM OBSERVATIONS

The teachers' stated perceptions are given in table 4 below

TABLE 4

STATED PERCEPTION	NUMBER OF TEACHERS
(1) Can be tested, is objective or can be proven	6
(2) Practical knowledge, leading to drawing conclusions, applicable to daily lives,needs you to explore existing objects	6
(3) Must not be far fetched	1
(4) Rules behind the working of things	1
(5) No articulated position	1

(a) Science represents knowledge that "can be tested" "is objective" or "can be proven". (six of teachers)

(b) Closely allied to this first criterion; science is "practical knowledge",leading to "drawing conclusions" which are "applicable to daily lives" and "needs you to explore existing objects" as well as a means of developing technology. (six teachers)

(c) One teacher argued that, in order to be regarded as scientific, knowledge "must not be far fetched". This teacher went on to explain that "If experiment is done it makes people understand clearer." This response may be taken as allied to the second one in which science is seen as "practical knowledge"

(d) One teacher saw it as "rules behind working of things"

(e) One teacher did not have an articulated position about the nature of science.

The teachers seem to adopt a mechanistic outlook on science in which the human element does not feature. Such an outlook may be informed by an empirical-analytical notion (Habermas, 1972, Schubert, 1986) of education in general and scientific knowledge in particular. According to Habermas (op cit 308)

> The approach of the empirical-analytic sciences incorporates a technical cognitive interest; that of the historical-hermeneutic sciences incorporates a practical one; and the approach of the critically oriented sciences incorporates the emancipatory cognitive interest......

Hence the role played by the social construction of knowledge resulting in a specific social identity or human face for science is not apparent. (Duschl, R A 1988) The role played by imagination and special interests in advancing scientific knowledge is also not apparent. (Hodson D, 1988; Geddis A N ,1988; Stinner A, 1989). It has been assumed earlier (8) that teachers' perceptions of science are reflected in what they **say** about it as well as what they **do** in class. Getting further insight into teachers' perceptions of science therefore entails investigating their classroom practices.

Classroom practices

TABLE 5

teacher	Classroom Observation
A	Practical demonstration of reaction rates.Lesson a tremendous success.Command of subject excellent
B	Kelvin temp scale. No logical connection shown by teacher.It turned out that he did not understand what triple point of water meant.
C	No lesson observed
D	Pupil activity encouraged
E	Lecture and notes. No equipment (destroyed in fire 2 years previously) Mechanical solving of problems rather than understanding was emphasized.
F	review of question paper. problems done by plugging in values into formulae.teacher readily admitted not understanding some of the physics involved.
G	solving problems on electrochemistry,done on board with some pupil input. Teacher lacked insight into salt -bridge processes
H	Lecture method used in lesson on chemical reaction rates.pupils apparently did not understand what was going on.they could not answer any of the questions put to them by researcher
I	General revision lesson using past papers no specific issues raised
J	Practical demonstration of solubility and precipitation, inadequate allowance for pupil observation before answer volunteered by teacher

K	Lecture and note taking coupled with question and answer in standard 10 organic chem similar method in 9.No demonstration of stated views about science
L	pupil activity in problem-solving was observed.No issues generated
M	No class visit conducted but a memorandum of a test had an illogical answer which the teacher was not prepared to debate with the researcher because it was "right"
N	An examination paper given to the pupils with the official memorandum being discussed afterwards. No specific issues raised
p	Video lesson on force boards and pulleys accompanied by worksheets. Teacher would stop the video occasionally to ask pupils questions.

A question was raised earlier about the extent to which teachers reflect on their teaching practice resulting in a dialectical praxis. Besides the limitations arising from a narrow philosophical outlook, most teachers are further limited by an inadequate qualification while some are further limited by insufficient experience in the teaching of physical science. In addition there is a limitation imposed by inadequate resources.

In four cases the teachers' classroom practices could be readily related to their stated views about the nature of science. For example one teacher conducted a practical demonstration of chemical reaction rates. Pupils were actively involved throughout. This teacher demonstrated a good command of the subject matter. It may be noteworthy that he had three years experience and a B Sc, B Ed. Although possibly limited philosophically, this teacher was not limited in his command of the subject matter. However given the teacher's outlook as well as the official curriculum, his practice was likely to produce "scientists" who operate almost entirely in the empirical-analytical mode.

In another case a teacher who stated that he saw science as "knowledge through practical observation and drawing conclusion", was on the whole satisfied with the present curriculum. In class he conducted a video lesson which involved a model lesson on force boards and pulleys prepared by the Department of Education and Training. He had hardly anything to add, but merely implemented a curriculum package. Pupils were then given a "worksheet" consisting of problems based on the video. This teacher who had a B A, B Ed and 12 years experience; had a reasonable amount of experience, but was not qualified as a science teacher. He seemed not to have a sufficient command of the subject matter to run "his own lessons" but relied heavily on ready-made curriculum packages. (consisting of videos, worksheets, and prepared lesson units with definitions, questions and answers.)

In another three cases it was not possible to relate the teachers' stated views about science and their classroom practices. In all three cases this occurred because the teachers did not demonstrate an adequate understanding of the subject matter themselves. Although two of these teachers had more than five years experience, none of them had degree courses in any Physical Science (One example is that of a teacher who attempted to teach the concept of the Kelvin temperature scale. It turned out that he, himself did not understand the concept of the triple point of water which is central in deriving the Kelvin scale from the Celsius scale. The logical link between the Celsius scale and the Kelvin scale could therefore not be shown. This particular teacher had said that science refers to knowledge that you can prove.)

In six cases it was not possible to directly compare and contrast the teachers' classroom practices and their stated perception of science. For example teachers may be supervising revision lessons using exam papers and memoranda (this study was conducted in August and September when teachers were beginning to drill pupils for examinations), or giving notes. Lessons given by an individual teacher vary from day to day and in some cases the perceptions of science represented by a given lesson are not readily perceptible. Nonetheless, even in this case teachers perceptions of science are revealed in what they do or fail to do in their lessons. For example, merely "implementing a revision lesson using memoranda from past papers, without giving a certain perspective in places, gives the impression of viewing science as a body of "objective knowledge to be transmitted.The nature of the lesson may be such that the teachers perception of science is not explicitly revealed by the lesson on its own. Clearly it would be significant if a teacher kept using curriculum materials which s/he did not prepare, which also do not represent his/her perception of science. If this is found to be the case,it would show that teachers are not free to teach as they think. However an analysis of the significance of a variety of teaching methods would require a case study. The purpose of this study is to analyze perceptions of science as revealed by what teachers say and what they do in class in a broad sense; assuming that perceptions of science are revealed by these two factors combined. The purpose of this is to demonstrate the extent to which the Official Curriculum represents teachers' interests. What this attempt to relate stated perceptions to teaching practice does show is that it is one thing to view science as "practical knowledge",that is "objective" or "can be proven",it is another to demonstrate these views in practice. A good understanding of the subject matter is required for this.

4.2 ANALYSIS OF THE OFFICIAL CURRICULUM

In chapter 2 the received notion of a "scientific method" was questioned and made problematic. Further an argument was made about the ahistorical nature of accounts of previous scientific achievements. It was argued that a combination of these two gives a dogmatic picture in which science is presented as being characterised by "inexorable progress" (Pearson 1892, cited in Stinner, 1989, 5). Further, the question of how the Official Curriculum portrays science was posed. This entails two questions about the official curriculum. Firstly, does the official curriculum present an ahistorical account of previous scientific achievements? An analysis of two of the most popular prescribed books, one of which was in the KwaZulu Department of Education school supply should give some pointers. Secondly does the

Official Curriculum encourage reflection about the nature of science on the part of teachers? (This question was posed in a different form in chapter 2). Answering this question entails analysing the aims, objectives and main points made in official syllabus documents in standard 8,9 and 10.

4.2.1 ANALYSIS OF SYLLABUS DOCUMENTS.

The syllabi for standard 8-10 Physical Science, as amended for KwaZulu (implemented in 1986-88, see Appendix 1) at the time this study was conducted, had broad aims with the following key-words: "subject knowledge", "skills, techniques and methods of science","scientific attitudes","scientific explanation","scientific language and terminology","application of science in industry and in everyday life"

There is neither an explicit definition nor a clear statement on the nature and structure of scientific thinking. Stated as they are the aims of the syllabus give no indication of the limitations of "science", however it is defined. On the other hand there is a reference to "scientific attitudes,....such as critical thinking" and "scientific explanation of phenomena"; as if this means the same thing to everyone. It can be argued that such omissions entail a hidden curriculum of "scientific objectivity", "scientific progress" and so on.

Feyerabend (1990, 1988, 1974) argues that in the twentieth century, science has displaced (Christian) religion from its former position of authority in Western thinking. It is possible to get a feel for this argument by imagining a missionary setting out from Europe to Africa, two centuries ago. Among his broad aims, this missionary may want to "teach the pagan natives some Christian attributes". (Words like "pagan native" are no longer used in polite conversation and writing, but were used as a matter of course less than fifty years ago. For example ,the author still has a copy of his original birth certificate ;with the categories:"Christian names" and "Heathen names"). These aims may include: "knowledge of the Bible" (contrast with "subject knowledge"),"Christian attitudes" (contrast with "scientific attitudes"), "a Christian explanation of revealed truths" (contrast with "a scientific explanation of phenomena"), "Christian language and terminology" (contrast with "scientific language and terminology"), "Christianity in everyday life" (contrast with "application of science...in everyday life"). Now, whatever attitude taken towards Christianity, it is not possible to miss the ideological slant of the hypothetical missionary's position. Is "science" as presented by the Official Curriculum deemed to be ideological in any sense?

If there **is** an ideological slant in the way science is portrayed, is it possible or necessary to eliminate it in seeking to achieve a democratic curriculum? Is it not sufficient merely to become aware of it? Roberts (1982) seems to give an answer to these questions in his article on "Developing the concept of Curriculum Emphases in Science Education". He coined the phrase "curriculum emphases" in explaining "alternative views about why students should learn science". According to Roberts :-

> A curriculum emphasis ,...is a coherent set of messages about science ..that ...can be communicated both explicitly and implicitly. (op cit 245)

Roberts proposes seven different curriculum emphases which he claims to be "exhaustive in terms of what has been tried" by 1982, if not "exhaustive in terms of what is theoretically possible in science education". The "curriculum emphases "developed by Roberts are useful in analysing the views about science and science teaching expressed by the Official Curriculum as reflected in syllabus documents. They are also useful in analysing teachers' perceptions of science and exposing the concerns expressed. It has been argued above (63) that teachers seem to merely embrace the notions of scientific progress and scientific objectivity. It has also been argued that the aims of the standard 8-10 syllabus give no indication of the limitations of "science" and hence entail a hidden curriculum of "scientific objectivity", and "scientific progress"

A consideration of the curriculum emphases developed by Roberts (1982) is then made in order to develop this argument. The first one is the following:-

> **The everyday coping emphasis:**
> science is an important means for understanding and controlling one's environment be-it natural or technological (246)

A statement of aims from the Official Curriculum that reflects this emphasis reads thus:

> To introduce pupils to the applications of science in industry and in everyday life. (refer to syllabus document in appendix 1)

In their arguments the teachers also make a reference to the importance of science in industry and everyday life as stated above. They also argued that the curriculum may be improved by making it more relevant to the demands of industry.

> **The "Structure of Science" Emphasis:**
> ...this ..is a set of messages about how science functions intellectually in its own growth and development....(such as)..the interplay of evidence and theory,the adequacy of a particular model for explaining phenomena, the changing and self-correcting nature of scientific knowledge, the influence of an investigator's "conceptual principles" (page 247)

It is noteworthy that teachers do not mention "the changing and self-correcting nature of scientific knowledge, the influence of an investigator's "conceptual principles" (ibid) in their responses. They merely referred to "testable hypothesis, knowledge that you can prove, look...how and why...can be tested"(66-?).

None of the broad aims of the syllabus refer to the structure of science per se, although reference is made to "critical thinking" (whatever that means). It therefore seems that teachers' views about the nature and structure of scientific thinking are neither **explicitly** supported nor contradicted by the Official Curriculum as reflected in syllabus documents. This omission, may well also entail a hidden curriculum of scientific objectivity referred to above (73)

> **The "Science, Technology and Decisions" Emphasis:**
> ..this one concentrates on the **limits** of science in coping with **practical** (the present author's emphasis) affairs. (page 247)

(The second emphasis above is introduced to draw attention to the fact that "science" may be seen as having **limited** usefulness in both **theoretical** and **practical** affairs.) In outlining this emphasis, Roberts goes on to argue that "a practical problem" wants a "defensible decision" whereas "a scientific problem" eventuates "warranted knowledge" (247). Roberts (op cit) uses this emphasis in arguing that personal and political decisions are value laden. For example decisions for or against nuclear power stations, genetic engineering and so on are not based purely on scientific risk analysis (if there is such a thing) but on the political influence and power that opponents and proponents have. The Official Curriculum does not show this dimension in its aims, nor do teachers argue for its inclusion in a new curriculum.

> **The Scientific skills development emphasis:**
> ...materials which embody this curriculum emphasis ...are directed towards developing fundamental skills required in scientific activities...The goal is not an accumulation of knowledge about any particular domain ...but competence in the use of processes that are basic to all science (Gagne 1966 in Roberts ibid 247).

The Official Curriculum makes mention of the argument:

> to develop in pupils the necessary skills ,techniques and methods of science ,such as the handling of certain apparatus the technique of measuring,etc (see paragraph 1.1.2 of syllabus in the appendix 1)

There was only one specific references to **skills** in the teachers responses. This was "..observation skills" .There were indirect references in responses such as "(pupils doing science).. must be able to wire houses...", "must study with an aim of application ", " thinking logically "and so on. On the whole the skills dimension is a concern that teachers also raise. Most of them do not refer specifically to "skills" possibly because they did not have sufficient time to reflect on the questions put to them.

> **The "Correct Explanations" Emphasis:**
> ...some ideas are accepted by the scientific community, while others are not....the substance of this curriculum emphasis is a set of messages about the authority of a group of experts to determine the correctness of ideas (247-248)

The Official Curriculum makes a reference to "scientific explanation". The hidden message here seems to be that if there are competing explanations for a given phenomenon, particularly a practical one, the explanation given by "scientific experts " should be accepted. The teachers do not make an explicit reference to this emphasis.It has been argued earlier that there is a scientific hegemony in Western thinking which has replaced a (Christian) religious hegemony. Even implicit references to "scientific explanations" as opposed to other kinds of "explanations" were hard to detect in the teachers' responses.

On the whole teachers seemed to be mainly concerned with the practical benefits of doing science; and did not explicitly address this ideological dimension. The "Correct Explanations Emphasis" may be contrasted with the next one discussed by Roberts (op cit 248),that is:

> **The "Self as Explainer" Emphasis**
> The messages constituting this emphasis deal with the character of science as a cultural institution and expression of one of man's many capabilities....To animate the history of science is to examine the growth and change in scientific ideas as a function of human purpose,and of the intellectual and cultural preoccupations of the particular settings in which the ideas were developed and refined.....The student thus gets the message that the humanity of science is his own humanity. The individual's idiosyncratic set of explanations for events he has decided to explain is seen as consistent and reasonable,given his purposes and preoccupations-the same construction as this emphasis puts on the explanations developed by scientists of an earlier time

This emphasis seems to be referring a perceived need to show the "human face" of science. It has been argued earlier that the Official Curriculum entails a Hidden Curriculum of scientific progress and scientific objectivity. Duschl, (1988) levels more or less the same kind of accusation against K-12 science programs (in the United States) in an article entitled "Abandoning the Scientistic Legacy of Science Education" in <u>Science Education</u> when he says that "....The prevailing view of the nature of science in our classrooms reflects an authoritarian view; a view in which scientific knowledge is presented as absolute truth and a final form" (op cit 51). This shows that the same concern can be raised about some foreign curricula.On the other hand the teachers did not present an argument for the need to show the human side of science.

> **The "Solid Foundation" Emphasis:**
> ...science instruction should be organised to facilitate the student's understanding of future science instruction....One manifestation of thinking about curriculum this way is the practice of recommendation by university science teachers about the nature and substance of adequate secondary school science instruction.(Roberts op cit 249)

The Official Curriculum does not explicitly refer to "future science instruction". However it can be argued that this is implied in the statement (on paragraph 1.1.1 of the standard 8-10 syllabus document) "to provide pupils with the necessary subject knowledge...." On the other hand four teachers explicitly argued for improvements to the Official Curriculum to make it more compatible with further studies.

A consideration of Roberts "Curriculum Emphases" seems to confirm the argument raised earlier that there is a Hidden Curriculum of scientific progress and scientific objectivity entailed in the Official Curriculum which seems to be embraced by the teachers, although more by default than by explicit endorsement. This becomes apparent if the "Science Technology and Decisions Emphasis" as well as the "Self as Explainer Emphasis" referred to above are considered. It has been argued that these emphases appear neither in teachers stated perceptions nor in the Official Curriculum.

It is also worth noting that when teachers teach their main source of information is prescribed books. An analysis of the official curriculum would be incomplete without an analysis of some of the prescribed textbooks. This is so because although syllabus documents stipulate what should be taught, the content that is actually taught comes almost entirely from prescribed textbooks in most cases. Although the prescribed books have slightly different "curriculum emphases" (Roberts, 1982 op cit), they all seem to subscribe to the notion of a "single correct scientific method".

4.2.2 ANALYSIS OF PRESCRIBED TEXTBOOKS

A good place to start may be with a section that traces the evolution of the concept of the atom in Brink and Jones'(1987) Physical Science 9, and Broster and James'(1987) Successful Science 9. It needs to be noted at the outset that both these books are written according to the prescriptions of the syllabi, and hence do not necessarily reflect the views of their authors.

In Brink and Jones as well as Broster and James this section tells of Dalton's atomic model(1803), Thomson's model (1897) which superseded the model by Dalton, Rutherford's (1911) model which superseded that of Thomson and finally, Bohr's (1913) model which superseded Rutherford's. (Bohr did not have the last word on the nature of the atom, but this was outside the scope of the syllabus in 1992 and was thus not discussed in the books, possibly giving the impression that Bohr **did** have the last word about this matter to those who do not study science further. In any case subsequent models may well be too complicated for those who do not intend to pursue science beyond high school level). The impression given is that the atomic model improved gradually because of the application of "the scientific method". For example Dalton is presented as having proposed a model to explain certain experimental observations. This model was subjected to further tests by other scientists. It was successful for some time but, eventually, it failed; leading to it's being replaced by the more sophisticated Thomson model. Thomson's model was in turn subjected to further tests and so on.

The books say nothing about whether there were other explanations, not necessarily involving atoms, for the experimental observations made by Dalton (in 1803), which are presented as having led him to invoke the concept of an atom; an idea that was conceived in ancient Greece but mysteriously remained dormant for centuries. Another impression given is that Dalton's model was easily refuted through application of the "scientific method", in the form of further experiments. **Apparently**, Dalton's model had no defenders, but was merely accepted by disinterested investigators. **Apparently** all experimental evidence pointed logically and unambiguously in the direction of Thomson's model. **Apparently** Thomson used logic rather than imagination in arriving at his model. The same argument goes for the way in which Thomson's model was eventually refuted and so on.

This ahistorical "historical account" of the development of the concept of the atom could have been omitted without any loss to the pupils' education in general and the science taught to the pupils in particular. It is not possible for anyone reading this account to get an accurate understanding of the beliefs held by scientists in the past, as well as the interests served by their scientific investigations. Instead of realities about how ideas develop, in the context of opposing ideas, which are informed by certain beliefs and rationalizations; the reader is fed a "fairy-tale" about the efficacy of "the scientific method" and how its dedicated application leads to "inexorable scientific progress".("inexorable **scientific** progress" is implied in "inexorable progress" mentioned by Pearson, 1892 in Stinner, 1989). Such tacitly understood "fairy-tales" in popular thinking about science may have led to a rise in the status of science up to the situation that exists presently when, in Feyerabend's view (1983, 1988, 1990) science has displaced Christian religion from it's former position of authority in Western thinking.

RELATING TEACHERS' IDEAS AND PRACTICES TO THE OFFICIAL CURRICULUM

This study investigated the reasons given by teachers for doing science, which should offer pointers to their initial perceptions of science, when they were still pupils. A comparatively large number (seven) saw science as a vehicle for science related careers and studies. An attempt was then made to investigate improvements that teachers would suggest to the present curriculum with this fact in mind. The teachers were largely concerned with making the curriculum more suitable for further studies as well as the world of work. The issue of a possibility of an ideological slant in the curriculum was not addressed by the teachers in this context. In their statements about the nature of science, which they saw as "practical knowledge" that "can be tested", "proven" or is "objective", (66) the teachers seemed to subscribe uncritically, by default at least, to the notions of "scientific progress", "scientific method" and "scientific objectivity". The fact that "progress" is a value judgement entailing several possible views, the existence of the "scientific method" is controversial, and "scientific objectivity" is contingent to the existence of the scientific method were not considered by the teachers. In three cases (68) the teachers classroom practices belied their statements about the nature of science; owing to their lack of understanding of the subject matter. The syllabus documents do not encourage reflection about the nature of science but give the impression that there is one "scientific method to be followed.

CHAPTER 5

5.1 CONCLUSIONS

In chapter 1 , it was pointed out that " teachers frequently complain that the science syllabi, books and work programmes, (the "Official Curriculum",) are not adequately designed to meet the educational needs of Black children." (2) In view of this it was expected that teachers may have objections to certain fundamental assumptions about the nature of science and science education entailed in the official curriculum. The expectation was that teachers objections would reflect dissatisfaction with ideological-political as well as cultural viewpoint of the official curriculum

"In their statements about the nature of science" (84) teachers "seemed to subscribe uncritically, both by commission and omission to received views about "scientific progress", "scientific method" and "scientific objectivity" (ibid). They tended to see science as a "vehicle for science related careers and studies". Further support for this view comes from their suggestions for improvements (op cit, 83) in which they "were largely concerned with making the curriculum more suitable for further studies as well as the world of work".

A question raised in chapter 1 (3) is whether the presentation of science in the official curriculum is congruent with teachers' perceptions of science. In particular an expectation was that teachers may object to the philosophical and cultural dimension of the official curriculum, and hence raise problems about the notions of scientific objectivity and scientific progress as well as show an awareness of the fact that these qualities attributed to science are premised on specific value systems. It has been argued, in chapter 4 (73), that the official curriculum entails a hidden curriculum of "scientific progress, scientific objectivity" and so on. It seems that the teachers involved in this study do not have any objections to the nature of science and science education as presented in the official curriculum, in fact, they endorse it.

The presentation of science in the official curriculum therefore seems congruent with teachers' perceptions of science in this regard. This finding may be expected as a natural consequence of the fact that the official curriculum tends to reproduce people with the same views as found in it. It therefore seems that teachers complaints which were identified in chapter 1 (2) were restricted to specific aspects of the official curriculum rather than the overarching philosophical view entailed in the official curriculum.

The aspects of logic and sequencing of topics, raised by some teachers, may be important from a didactic point of view, but do not address epistemological issues which may have a bearing on whether it is emancipatory or tends to reproduce the present social structure as natural and true.

Issues relating to the impact of science and technology on society and the importance of these in the curriculum are not raised by the teachers in their suggestions for improvement to the present curriculum. For example, environmental issues such as acid rain, the greenhouse effect, and the depletion of the ozone layer, which are a direct result of industries and industrial products, are not raised. Issues such as the proximity of polluting industries to residential areas and the disposal of toxic and radioactive waste are also not raised. Scientific and technological development is presented as value neutral by omission both in teachers perceptions of science and in the official curriculum.

Inclusion of examples relevant to the everyday life of pupils may also address the didactic point of view and thus possibly satisfy the teachers, without necessarily challenging the tone or epistemological assumptions of the official curriculum.

Involvement of the private sector in curriculum development and the inclusion of topics which have a relevance to industrial pprocesses, certainly does help in increasing the employment prospects of school leavers, but does not necessarily address fundamental issues either. Industries may want better qualified workers, in order to be more profitable, but may not necessarily want people with an awareness of the possible harmful effects of their products. Such issues need to be dealt with by people who do not have an interest in the profitability of specific industries.

5.2 RECOMMENDATIONS

5.2.1 RECOMMENDATIONS FOR CURRICULUM DEVELOPMENT

Efforts at curriculum development should go hand in hand with efforts to unearth ideological assumptions which tend to reproduce certain forms of inequality and hence defeat attempts to democratise the curriculum. An example is the possibility that a scientific hegemony has replaced a (Christian) religious hegemony in Western thinking; a view expressed by Feyerabend and alluded to in chapter 4. (Although Feyerabend did not use the word "hegemony", which is favoured by professed neo-Marxists such as Apple). This possibility was raised in a context when it was pointed out that achieving democracy in education may entail an awareness of the present "hegemony".

Hence, it can be argued that ostensibly scientific educational practices which have been suggested as remedies to Apartheid education by government appointed bodies may also involve the same type of oppression (albeit more covert) as the Apartheid education they are supposed to replace. Reforms like these have been labelled as "technicist" (Buckland 1984). Such "technicist" reforms were suggested as alternatives to Apartheid Education which drew its philosophical base partly from the Christian National Education movement of 1948.(Kallaway 1984)

Buckland (1984, 371-372) cites a definition proposed by Manfred Stanley (1977), that technicism is manifest in "the illegitimate extension of scientific and technological reasoning to the point of imperial dominance over all other interpretations of human nature". In supporting this statement, Buckland also argues that:

> The important thing is not that the technological mode of rationality is "wrong" in itself, but simply that its application to social and educational issues **to the exclusion of all other modes of knowing** means that it tends to act as a set of lenses which focus only on certain issues and avoid others.(372)

A question can then be raised as to whether present initiatives by the government go far enough in addressing fundamental issues in education or merely operate in this technicist mode. This is in addition to a consideration of whether such initiatives do in fact address the concerns of teachers' and other stakeholders.

In this regard a good starting point is the CUMSA (Curriculum Model for Education in South Africa) document published in 1991 by the Department of National Education and presently (1993) used as a discussion document in curriculum reforms by the various established education departments. Some guidelines from this document are that:

> The development of a curriculum should take place in such a way that it is eventually the product of a general process of participation in which its consumers, especially, have been included. A structure of broad guidelines, within which such a process could successfully take place, should be established by **consensus** (my emphasis)(1)

Given that deciding what should be learned involves questions of value as well as "fact" , achieving consensus seems problematic. If "consumers" refers to all stake holders, is consensus possible or desirable anyway? Making a decision about the desirability of this "consensus" is one problem; its possibility is another. A suggestion in this document is then considered:

> .....the emphasis in the revision should, <u>inter alia</u> fall on **rationalising** (my emphasis) the curriculum and making it relevant (4)

How is the curriculum "rationalised"? Is it rationalised to achieve consensus or does rationalising occur after consensus has been achieved? The following statement may be considered:

> The first step taken in the development of a model for a revised broad curriculum was a **scientific investigation** (my emphasis) conducted by the South African Council for Education (SACE) in order to identify sound guidelines for the development of a broad curriculum for pre-tertiary education.(4)

A possible synthesis of these statements is that the curriculum can be "**rationalised**" if adequate **deference** is made to "**a scientific investigation"** conducted by the South African Council for Education". "Consensus" can then be achieved in this way.

Should deference be made to this "scientific investigation" ? Who appointed this "South African Council for Education" anyway? Whose interests does it serve? Hopefully these rhetorical questions show that genuine consensus may not be possible particularly given this country's history of Apartheid and other oppressive ideologies as well as diverse political and cultural groups.

Is consensus desirable anyway? Advocates of "Marxist conflict theories" seem to think that consensus is neither possible nor desirable. The arguments given seem to show that **free** consensus is not possible because different people in different communities do not think alike. Hence consensus in all educational matters can only be achieved if certain values and ways of thinking are ignored or suppressed. Consider the following statements by Apple (1979, cited in Buckland 1984, 373)

> ...the advocacy of consensus and the negation of intellectual and valuative conflict...tends to lead to a shift in focus from moral and ethical questions towards a focus on questions of efficiency and control

Apple made this statement while analysing educational problems in America. This argument serves to reinforce the point made earlier that curriculum issues involve value judgements. An attempt to be scientific about curriculum thus results in a neglect of **subjective** moral and ethical questions and a focus on **objective** questions of efficiency. The fact that Apple makes this remark in the American context, serves as further evidence that the scientific hegemony referred to above is a worldwide phenomenon. Apple (1990) also argues that depicting science as involving consensus involves a misunderstanding of scientific method as it is presently understood. To back up his argument, Apple cites Kuhn (1962). In a book entitled "<u>The Structure of Scientific Revolutions</u>", Kuhn argues that doing science sometimes involves disagreements and even complete breaks with tradition.

What is worth noting is that Apple locates his argument within a scientific paradigm. In other words he probably would not reject the notion implied in the CUMSA document, that curriculum design and development should be scientific; but merely argue that initiatives like this one do not represent proper science. This is abundantly clear in his attack on what he terms as "Systems management and the ideology of control" (op cit 105). Further, Apple (1990, 1) says "..neo-Marxist argumentation seems to offer the most cogent framework for organising one's thinking and action about education". He does not directly claim to be a neo-Marxist but admits having neo-Marxist sympathies. It is possible to raise issues about the extent to which Marxism is useful as a critique in this country, given that it was developed to address the problems of Western industrialised countries. Young (1978) alludes to these issues in considering Marxist analysis as a tool for critique. He expresses Marxist concerns in this regard thus:

> Much of this social criticism ,and the alternatives implicit in it, has been based on a new absolutism, that of science and reason. Today it is the commonsense conceptions of "the scientific" and "the rational",together with various social ,political and educational beliefs that are assumed to follow from these that represent the dominant legitimizing categories.(op cit, 3)

Young rightly points out "the dogmas of rationality and science become open to enquiry". (op cit, 3) Young seems to endorse the notion of the existence of a scientific hegemony. Marxists and neo-Marxists would probably agree with Young in principle at least. The extent to which they do in fact question "the dogmas of rationality and science" (ibid) in practice as opposed to "bad science" is another matter.

It is clear from the arguments above that Marxist analysis is useful in exposing ostensibly scientific alternatives to Apartheid Education. This analysis seeks to liberate people from oppressive, taken for granted categories by exposing these as ideological inventions which serve the interests of the ruling classes. For this reason this analysis seems to be a powerful tool for exposing injustices in Western "advanced" industrial countries. It is clear for example that when Apple speaks of "hegemony" he is referring to specific capitalist values that are taken as natural, true and not open to criticism. However he is certainly not referring to the entire stock of Western cultural values and scientific rationality.

In this regard, Marxist analysis seems to fall short as a tool in former colonies which make up what is presently called "the third world". As Ngubane (1991) points out Marxists (in their pre-occupation with capital) tend to depict oppression and injustice entirely in economic terms. Marxists either ignore naked racism and Western cultural hegemony or re-interpret these in capitalist-class terms in their "analyses of injustices". For example in the "Right to learn" (1985, 22) it is stated that:

> Class theorists argue that South Africa is basically a capitalist society. Race may appear to be the main reason for social inequality, but this is only the way things seem.In fact class conflict is the basic conflict in a capitalist society like South Africa.
>
> As we have seen conflict thinkers are concerned with **fundamental** values of society. They are often known as "radicals",...

Admittedly this may not be the best "argument" for seeing South Africa as a capitalist country. Nonetheless it may be pointed out that the opening statement "South Africa is basically a capitalist country" warrants an argument for the sake of those who do not think so. Instead of an argument the opening statement is simply repeated in different forms. The "conclusion" is that those who are "concerned with fundamentals" see South Africa as a capitalist society. This is not an argument but transparent Marxist rhetoric.

A clear recognition of the fact that curriculum development involves values rather than "science" has to be made. Involvement of stakeholders in curriculum development has to go hand in hand with this in mind. There may be a need for curriculum workshops with various stakeholders in which issues like the nature of science, some aspects of the history of technological and scientific development as well as the impact of science and technology on society are raised. This is in line with the concerns raised by one of the teachers that he needs exposure to curriculum materials. However this approach goes further in that a recognition of science as a process involving interests of various people and societies and interactions between these is involved.

The analysis of results shows that teachers are concerned with getting a curriculum that is more relevant to industry. This is understandable given that schools have to produce future workers in all industrial societies. In this regard the active involvement of industries in schools suggested by some teachers may be welcome. The question of preparation of pupils for work raised by the teachers seems valid and needs to be addressed. This question seems to be alluded to by the CUMSA document (22) when referring to:

> the vocational world where the subject content is of particular value-therefore also an early form of orientation and exploration.

There is therefore a recognition of teacher's concerns in principle. Whether this will translate to a recognition in practice is another issue. (In any case the CUMSA document may well be declared irrelevant and discarded in toto in the near future.)

5.2.2 RECOMMENDATIONS FOR IN-SERVICE AND PRE-SERVICE TRAINING

It was pointed out in the first chapter that there is a shortage of qualified and experienced Black teachers. Given a future non-racial educational system and the fact that Blacks are in the majority, this translates into a shortage of qualified and experienced science teachers in general. However the main concern of this study is teacher training and upgrading in the context of perceptions of science, with a view towards encouraging a process approach to education. More extensive pre-service training is necessary in the long term, to make up for this shortage. Such pre-service training should preferably focus on showing that science is a process that involves certain choices and practices which are in turn determined by certain beliefs and values. Such courses should address the debates about the nature of science as well as the epistemological assumptions involved in science education. An exposition of such debates has been attempted in chapter 2

In the short term recognition has to be given to the needs of teachers who are presently in the field and may need to be upgraded through in service training.

In this context Duschl (1988) argues for different kinds of science curricula for those who want to train as scientists and those who need science for their general education. The thrust of Duschl's argument is that less than four percent of the pupils in America end up with science degrees. The rest merely need science for their general education. Duschl argues that:

> ..a principal objective of science education should be to broaden the focus of course objectives beyond what is known by science and begin to include topics which examine how scientific knowledge and technology develop. The need is to have the scientific enterprise and scientific views represented accurately by recognising the strengths and limitations of each. (52)

Duschl's argument is that it is well and good for those who go on to specialise in science to study what is known by science. However those who do not go on to become scientists may be better served by a course that shows "how scientific knowledge and technology develops" and hence be in a better position to perceive the social context of science and understand it as socially constructed knowledge that serves specific purposes.

From the analysis of results it seems that teachers embrace views of scientific progress and scientific objectivity. As explained earlier while this may partly arise because teachers did not have sufficient time to reflect, it is likely to be a reflection of the kind of curricula that teachers were exposed to as students and are thus reproducing. Clearly, if Duschl's recommendations were adopted in this country teachers would also have to study courses on the social context of science in order to teach them to pupils who may not go on to study science at tertiary level. Further such courses would go a long way towards putting science in perspective.

Coupled with the notion of "scientific progress" and "scientific objectivity" is the notion of a "scientific attitude". In an article entitled "The Scientific attitude and Science Education", published in Science Education, Gauld (1982, 118) argues that "development of the scientific attitude in students should be eliminated as one of the major goals of science education". The main thrust of his argument is that the notion of a " scientific attitude" is premised on a belief in the existence of "the scientific method" which all successful scientists follow. Gauld argues that the notion of "the scientific method" is out of date. The present author does not necessarily argue for elimination but for qualification and/or justification if "scientific attitude" is mentioned.

Another issue that needs clarification is the extent to which schooling is for work in the present context or for mere intellectual satisfaction. Teachers have shown a concern about making the curriculum more suitable for work. Further, in this context they have suggested changes to the logical rather than the ideological structure of the curriculum. The type of courses suggested by Duschl should go a long way towards raising awareness of this ideological dimension.

The world is what it is, in the everyday sense, not so much because of science that is known but because of the principles of science that are **applied** in technology. The cutting edge of technology uses principles that have long been superseded in the cutting edge of science. The space programme, in its use of Newtonian mechanics is a classic example. Further, the cutting edge of computer technology uses basic principles of electricity and electronics and does not involve neutrinos and quarks. A lot of science done at school such as basic quantum mechanics and hybridization of atomic orbitals is not applied in industry at present. Appeals for science that is relevant and based on everyday observations by teachers seem justified on these grounds. Duschl argues that in America less than five percent of the general population have degrees in science.(In this country this number is probably lower by at least a factor of ten). While there may be a need to reserve certain topics for the few people likely to become research scientists, most people derive more benefit from topics that are presently being applied in industry. They also need to be liberated from "scientistic ideologies" (Duschl op cit) by being enabled to locate science in its social context as "socially constructed knowledge" which serves specific interests (Habermas 1972).

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APPENDIX A

AIMS OF THE SYLLABUS: PHYSICAL SCIENCE (HIGHER GRADE) :

1. INTRODUCTION

1.1 AIMS

A few general or broad aims of physical science teaching are the following:

1.1.1 to provide pupils with the necessary subject knowledge and comprehension, i.e knowledge of the subject as science and as technology;

1.1.2 to develop in the pupils the necessary skills, techniques and methods of science, such as handling of certain apparatus, the techniques of measuring, etc.;

1.1.3 to develop in pupils the desirable scientific attitudes, such as interest in natural phenomena, desire for knowledge, critical thinking, etc.;

1.1.4 to introduce pupils to the scientific explanation of phenomena;

1.1.5 to introduce pupils to the use of scientific language and terminology;

1.1.6 to introduce pupils to the application of science in industry and in everyday life;

1.1.7 to help pupils to obtain perspective in life, for example to develop a reverence for the Creator and an esteem for the wonders of the created universe through contact with the subject matter.

It is left to the teacher to specify the objectives of each topic and lesson. This implies that specific objectives are related to specific subject matter, methods and evaluation.

1.2 REMARKS

1.2.1 In teaching the syllabus it will be necessary to make use of simplifications. The simplification, however, must not be such that the pupils are left with serious misconceptions. Where conceptual models are used to simplify the explanation of certain phenomena (e.g. Rutherford's model of the atom) it must be made clear that these are <u>models</u> and, as such, are not intended to serve as fully acceptable scientific explanations.

1.2.2 S I units must be used throughout.

1.2.3 Wherever possible, concepts and principles as set out in the syllabus must be demonstrated

APPENDIX B

INTERVIEW SCHEDULE

The questions in this schedule form part of my study towards an M.Ed degree at the University of Natal.They provide knowledge that may be useful in the context of Curriculum development.There are no "correct answers" to any of these questions; only opinions and views and nothing more than that(although we are usually given the impression that there are correct answers to all questions on educational matters).[What usually gets "bandied about" as "correct answers" are in reality the views of "experts" with certain interests ,political and otherwise.]

Teachers,especially Black teachers, have in the past not been consulted in matters pertaining to the Curriculum(syllabi work programmes and all other teaching aids).With more and more people advocating a "democratic approach to curriculum decision-making that may soon change. this interview schedule is to be used among Physical Science standard 8-10 teachers only. In this context "Science" refers to "physical Science"

QUALIFICATIONS:

EXPERIENCE:

(1)(a)What circumstances led to your specializing in science as a pupil at school?

(b)What additional factors led to your deciding to be a science teacher?

(2)(a)What skills, attitudes and attributes do you expect pupils to acquire by studying science?

(b)In what way are the pupils going to benefit from these?

(3)(a)What do you understand to be the nature of scientific knowledge?

(b)Do you think scientific knowledge differs at all from other forms of knowledge?

(c)Can you explanation your answer?

(d)Did Blacks have any scientific knowledge before the advent of "Western civilization" in you opinion ?

(4)What do you think has led to the view that science is a difficult subject which can only be attempted by "gifted "pupils?

(5)(a)To what extent do you think the present standard 8-10 Science curriculum enables pupils to develop the skills attitudes and attributes which you identified earlier?

(6)In the context of the "New South Africa" it is probable that Blacks are going to be involved in Curriculum Development(that is in decisions on what should be taught at what levels and how it should be taught) in science.

(a)Do you think it is a good thing to consult teachers on science curriculum development,or would you rather leave the whole thing to experts?

(c)What reasons can you give for your answer?

(7)The above questions not-withstanding you may well find yourself being consulted in future science curriculum decisions. If consulted what changes would you suggest to the science syllabi/work programmes in standard 8-10?

(8)How, do you think is science related to technology?

(9)What are the problems militating against successful science teaching in your school?