Intercultural Science Education and 'Late Modernity' – a Comparative Study between Portugal and England

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Doing a Ph.D. is far more than developing research and writing a thesis. It is a process of internal change, which promotes intellectual and emotional growth. It is thus a period in one's life, which demands a lot from oneself but also from all the others that surround us. It is difficult to mention all of those (too many!) that accompanied me during such a process. To all of them I express my gratitude.

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Abstract

With this thesis, the researcher hopes to contribute to the understanding of the role of 'the' ideology of modern science in the promotion and transmission of understandings of cultural difference, which can empower Western culture, via science education. Ultimately, she aims to contribute to the debate on the nature of intercultural science education.

The thesis involves a comparative discussion of specific aspects of science education in Portugal and England. It is mainly centred on compulsory science education curricula. It is supported by analyses of state understandings of cultural difference and modern science in these two countries. The comparative study derives from a general discussion, within the Western European context, of state education and of the role of 'the' ideology of modern science in the definition and promotion of understandings of cultural difference, which developed in a parallel form to processes of nation-state formation. This discussion is historically oriented. The research questions and comparative principles that orient the comparative study derive from it.

In the thesis, the author argues that science education in both Portugal and England also developed as a socialising means regarding issues of cultural difference. State science education has been oriented by economic aims. Generally, these depend on a positive acceptance of scientific knowledge. The promotion of 'the' ideology of modern science seems to have been basic for that. However, this ideology tends to have associated the support for understandings of cultural difference, which can empower Western culture. This being the case, it can have profound negative implications in and for culturally diverse societies. In terms of the nature of intercultural science education, questions relate to the possibility of teaching modern science apart from its ideology, or of teaching a different subject, defined by a broader, more inclusive concept of science, of which modern science is only one element.

Table of Contents

Chapter 1

Introduction

Introduction

This chapter introduces the thesis. It considers the researcher's motivation for the study, along with the general aims and rationale for the study. Elements are also presented regarding several of the choices made so as to make the study possible. The relevance of the study along with its innovative character is presented. So is the case for the structure of the thesis.

1.1 Origin, Aims and Rationale of the Study

Motivation for the Study

This study resulted from a combination of several academic interests of the researcher. She understands state education in culturally diverse societies as a main reflector of the dialectic processes between states, dominant nations and cultural diversity regarding state needs and societal educational demands. She is particularly interested in issues that relate to the nature of scientific knowledge. Specifically, she is concerned with the relation between education, modern science, politics and economy in culturally diverse contexts. The focus of the study is on science education in such contexts.

Modern science has traditionally been seen as the source of truthful answers. Contemporary societies contest scientific and technological results, which have produced both important negative and positive outcomes. However, societies continue to rely on modern science for improvement. Regarding cultural diversity, for example, modern science has been used as a means to legitimise the concept of 'race'[1] and as a means to de-construct it. Which one is then the true answer regarding this concept, one may ask?

The researcher was trained to be a physicist and thus she had close contact to modern science and to means of its production. Later on, she decided to teach physics. While doing so an intriguing question has arisen from a comparison between the real world of modern science's production and guidelines for teaching such a discipline: why does science education tend to portray models of modern science which are different from the reality of modern science?

The researcher had always been interested in issues of knowledge production and in their relation with power. Consequently, the immediate following question that was put to her related to whom does science education serve, and moreover, with which purpose?

These questions have a general nature. The specific interest of the researcher in culturally diverse contexts, which are the reality of contemporary societies, prompted her to focus her thoughts on particular aspects of science education in such societies as the next discussions will show.

General Aims of the Study

The study endeavours to contribute to future developments of science education that can contribute for fairer and less discriminating, less racist and less xenophobic societies. It tries to contribute to a better understanding of the nature of intercultural science education in Western Europe, particularly in Portugal and England. While doing so, it also hopes to deepen comprehension of the intricate relation between education, modern science and images of it, dominant nations, states and cultural diversity in Portugal, England and Western Europe.

General Rationale

The thesis constitutes an analytical discussion, which involves a comparative study between Portugal and England. It is divided into two main parts that are connected by a linking chapter. This establishes the rationale for the comparative study. It presents the comparative principles and research questions, which derived from the first part of the study. The latter discusses aspects of the relation between nation-states, cultural diversity and modern science and its ideology in the general context of Western Europe. The reflection of such a relation in education, specifically in science education, is then discussed. Particular attention is paid to intercultural education and to intercultural science education. An historical perspective is taken, and examples are used, particularly from the cases of Portugal and England. This part of the study derives from specific literature with which the researcher generally identifies. Consequently, the discussions are not comprehensive and they do not attempt to portray different understandings of the same reality. They constitute an attempt to develop an analytical framework which will be the basis of, and support the comparative study.

The second part of the study follows a similar orientation to the first one. It focuses on the particular contexts of Portugal and England in a comparative manner, referring to the established comparative principles and research questions. Consequently analyses are carried out regarding issues of cultural diversity, nation and state formation and attempted maintenance, and modern science and its ideology referring to Portugal and England; such is the case for the reflection of these issues in state education, specifically in science education in these two countries. Particular attention is paid to the Portuguese and English curricula of physics, biology and chemistry at the compulsory education level. Specific attention is also given to intercultural education and to intercultural science education in both countries. Historical analyses are considered too. A concluding discussion ends the thesis, while suggesting new research problems.

On the Choices Made

In order to develop the study several choices were made. The next paragraphs try to explain and justify them.

Choice of Context

The study is centred on Western Europe, particularly focusing on Portugal and England. The concepts and entities of nation-state, modern science, and state education have their oldest basis in Western Europe. The discussion of a broad context was perceived as an enrichment of the more narrowly contextualised analysis. Broad analyses encase contextualised ones. Those on Portugal and England can reinforce the ones on Western Europe. Western Europe is mainly considered as a geographical category. References to the EU are also made, yet this category and that of Western Europe are considered the same in the thesis.

Other categories are used in the thesis. That is the case for those of West and Western culture. The researcher is aware of the eventual ambiguities that the use of these categories may cause. Economic and political change produced other categories and introduced de-constructions of the ones mentioned above. However, and in spite of that, the researcher persisted in using them although with particular considerations and within general definitions. The next paragraphs present and explain such definitions and considerations.

Even if de-construction of categories has characterised contemporary academic and, to a certain extent, political discourse and debate, in reality there seems to persist a global dominance of elements which derives from the original categories of West and Western. One has been observing a global tendency for an approach (forced or voluntary) to elements associated with capitalism and traditional Western ways of living. It is true that reaction against this approach is found in many localisms. Yet, globalisation seems to have been powerful in spreading a common way of life with specific associated values. In this thesis the category of West refers to this now broad category of common ways of life and cultural elements which in turn derive from democratic and capitalist societies such as those of the EU or the United States of America. The category Western relates to this West.

One could, however, argue that the study focuses on Portugal and England and thus the use of the category Western Europe should be enough. Yet, a great deal of the discussion on cultural diversity involves issues prevalent in other parts of the world and eventual elements of cultural imperialism, which are not now simply related to Western Europe. One can no longer consider the traditional relation between former colonisers and colonies, for example. Other countries such as the USA are active and influencing participants in the contemporary jigsaw of political relations between states and definitions of cultural diversity. Moreover, Western Europe can be seen within the West category. Consequently, this category will be important at some points of the discussion. It will be presented with inverted commas so as to make clear its nature and the acknowledgement of its complexity. This will also be the case for the categories Western and Western culture.

Western culture will be considered in this thesis also in a broad sense. Fundamentally, it will denote cultural elements, values and ways of life associated with democratic and capitalist societies, again such as those of EU countries or the USA. When processes of westernisation are considered in the thesis they directly relate to societal movements approaching the model of West associated with such societies.

Within Western Europe a choice was made, focusing the study on Portugal and England. The choice of these two countries derived from particular interests of the researcher. She is Portuguese and has developed several of her studies in England. This led to the growth of a specific interest in these countries and in eventual influencing processes occurring between them. She is particularly interested in possible movements towards westernisation (as above considered) developed by Portugal during the past decades. Moreover, unlike in England, few studies on intercultural education have been developed in Portugal. The study is designed as a comparison.

Comparison

Portugal and England are both members of the European Union. They share the same political/democratic orientation; they share similar economic and social interests; they are perceived within the same broad cultural framework. They are now culturally diverse societies with a common past of colonialism and imperialism. However, such was not entirely the case until as late as the 1980s when democracy and economic development finally stabilised in Portugal. European Union membership was fundamental for such stabilising. Portugal pursued a path of modernisation by attempting to achieve social and economic levels similar to those of its northern European Union counterparts. At the same time, it had to come to terms with changes of cultural identity. Studying both countries in a comparative way can not only contribute to understanding the relation between education, states, cultural diversity and modern science in each society, but it can also permit a better comprehension of processes of westernisation going on within the EU.

State Science Education

The study of Portuguese and English science education is oriented by an analysis of aspects of the interaction between education, cultural diversity, nation, states and modern science and images of it. In particular, education is considered in terms of states' uses of it. Thus, the analyses of science education presented in the thesis refer to state science education, even if the word state is omitted.

Within state science education the chosen focus of analysis was on formal education. Issues on educational policy and curriculum are considered[2]. Formal education is directly related to the state, particularly in centralised educational systems. Both Portugal and England have national curricula compulsory for the majority of the school population[3]. These curricula generally reflect the states' comprehension of modern science and their demands from it for their societies. Informal science education can be freer from state influence than formal education.

Within formal science education a choice was made for compulsory education. The reason behind it relates to the relatively universal nature of compulsory education. In secondary education students can opt for different subjects. Not all of them will be exposed to the same science education curriculum. Such is not the case with compulsory education. In this sense, the curriculum corresponds to what the state demands from its population in terms of learning of modern science and what is considered fundamental for general basic education regarding this subject.

Within formal, compulsory science education the study focuses mainly on issues of curriculum and policy. No educational practice is considered. Educational practice is directly related to the delivery of state education. Various factors influence it, varying from the school policy to teachers' own understandings of the nature of science education and modern science. These factors may alter the original state comprehension of and demands from science education. Consequently, since this thesis attempts to focus on reflections on education of state understandings of modern science, cultural diversity and societies, the study of educational practice was disregarded.

Modern Science and the Natural Sciences

Modern science is one of the elements of the study. (A discussion on this aspect will be held in the next subsection.) The analyses in the study relate to scientific developments and understandings of science, which occurred in Europe from the seventeenth century onwards, and which were later spread to the rest of the world. Such a spread developed in terms of both means of knowledge production and understandings of the nature of scientific knowledge. Quite often, these developments and understandings are taken as science. However, they tend to neglect other knowledge evolving and non-European comprehension of science as well as other participation in general scientific knowledge production. In order to report to the particular knowledge and means of knowledge production developed in Europe from the seventeenth century onwards, in the thesis, the word science is replaced by the expression modern science, as has already been the case in previous texts.

Modern science involves both natural and social sciences. The relation between Modern science, nation-states and education involves both the natural and the social sciences. The analyses in the thesis concern the natural sciences. The social sciences are also considered but in a secondary supporting role. Throughout the text, and for reading convenience, the expression modern science is used to designate both modern science as a concept and the natural sciences that compound it. The emphasis put on the natural sciences results from the acknowledgement of its societal importance in and implications for contemporary, culturally diverse societies. It is also a result of the researcher's particular interest in the natural sciences due to her previous studies in physics.

Throughout the thesis, references to technology are also made. Expressions such as 'modern science and technology' or 'scientific and technological development' are used. It is not a thesis aim to discuss the nature of technology. In the study, technology is always considered in association with modern science. Technological development influences scientific development and vice-versa. The notion of technology used in the thesis considers it in the dependency of modern science without however denying its importance by itself.

The Ideology of Modern Science and the Scientific Method as a Discursive Strategy

Although the study refers to modern science, its focus is in fact, on the ideology of modern science. The author chose to take no position in regard to the nature of science. Moreover, she looked at the scientific method as a discursive strategy.

The academic debate that followed the work of Karl Popper and Thomas Khun opened a discussion on the nature of scientific knowledge that is still very vivid. While Popper's work implied the acceptance of an equivalence between modern science and science (Popper, 1963), Khun's work opened up other possibilities. By introducing the concepts of scientific revolution and of paradigm change, and by setting up questions such as 'is sensory experience fixed and neutral?' (Khun, 1996, p.126), this philosopher gave room to the development of understandings of the concept of science that could go beyond that of modern science. Kuhn proposed the idea of paradigm, as well as that of paradigm change, in association to those of worldview and, in fact, change of worldview. In his words:

> At times of revolution, when the normal-scientific tradition changes, the scientist's perception of his environment must be re-educated – in some familiar situations he must learn to see a new gestalt. After he has done so the world of his research will seem, here and there, incommensurable with the one he had inhabited before.' (Khun, 1996, p.112)

As in fact,

> What a man sees depends upon what he looks at and also upon what his previous visual-conceptual experience has taught him to see. (Khun, 1996, p.113)

Paul Feyerabend went beyond Khun's ideas by proposing the non-existence of a single scientific method (Feyerabend, 1992). He proposed the existence of various methods, and strongly criticised the positivistic approach to science. Furthermore, he accepted the notion of modern science as a possible form of science (Feyerabend, 1992).

The author of this thesis acknowledges such a debate on the nature of science. However, it is beyond the aims and scope of the thesis to discuss the debate. Furthermore, the author has chosen not to take a position on it. She axiomatically considers modern science as defined in the subsection above: a body of knowledge, with an associated means of knowledge production, which developed in Europe from the seventeenth century onwards. Similarly, she also considers that associated to modern science (as defined above) one finds a particular discourse on it, that developed from the nineteenth century onwards, and that she designates by the ideology of modern science.

The study focuses on the ideology of modern science and not on modern science itself. In order to so, the author chose to look at the scientific method as a discursive strategy. Consequently, whenever critiques are made they do not refer to the scientific method itself, but to the discourse on it that can be found in the ideology of modern science.

It is not the author's intention to study the ideology of modern science. The latter is also axiomatically considered. What she hopes to do is to see possible implications of the presence of this ideology in science education.

Although the author does not take a Foucauldian approach, she incorporates into the study some elements of Foucault's analytical framework. Foucault considered that

> The question of ideology that is asked of science is not the question of situations or practices that it reflects more or less consciously; nor is it the question of the possible use or misuse to which it could be put; it is the question of its existence as a discursive practice and of its functioning among other practices. (Foucault, 1972, p.185)

In the thesis, the scientific method is not looked at in terms of its use or even its definition. It is looked at as a discursive strategy that may have important implications in the ways by which cultural difference is conceptualised. Given the ideology of modern science, in which a discourse on the scientific method is found, questions can be posed as to how this discourse may contribute to the construction of particular notions of cultural difference that can be embodied in cultural imperialism. This is not to question whether the scientific method itself can or can not contribute to the construction of such notions of cultural difference.

It is in this framework that the scientific method is taken as a discursive strategy in the study. Consequently, all through the study, the author does not seek to critique straight science. She seeks to critique the ideology of scientific method as it is manifested within education in England and Portugal.

Scope and Limitations

This study derives from a particular set of literature. The author considered the works of Kuhn (1996) and Feyerabend (1978, 1992). She also considered other authors within philosophy and sociology of science such as Fuller (2000), Hall (1962), Brooke (1990), Outram (1990), and Porter (1990b). The work of these authors attempts to discuss modern science in its relation to societies, and the ways by which scientific knowledge is produced. Kuhn's work on the nature of scientific knowledge production, and that of Feyerabend on the nature of the scientific methodology were fundamental for the development of contemporary discussions on the nature of modern science. The other mentioned scholars looked at modern science from a critical point of view, and discussed ideologies of modern science, in particular the one considered in the study.

The chosen literature is far from comprehensive and this constitutes one of the study's limitations. This is so, as the discussions resulting from the literature review do not present different perspectives on issues on the nature of modern science and discourses on scientific knowledge. They focus on a particular discourse on modern science. All others are disregarded. The reason for such a choice relates to the author's interest in the strength of the ideology of modern science and in its ability to exist over time. She was interested in discussing possible results of such an ideology for culturally diverse societies.

One of the results of such interests and choices was the design of a study which is of a conceptual nature. The author wanted to discuss the possible results for culturally diverse societies of the permeation of the ideology of modern science in Portuguese and English science education curricula. Given such an ideology, her aim was to try to discuss how the latter relates to discourses on cultural difference. If the ideology of modern science is present in Portuguese and English science curricula, given the discussion on such an ideology and discourses on cultural difference, analyses can be made about possible consequences for culturally different students. Ultimately, the thesis aims at trying to understand how a particular ideology of modern science may be influencing discourses on cultural difference in culturally diverse societies. It looks at such discourses and relationships between them in science education in Portugal and England.

Due to the nature of the discussion – the relationship between two discourses and possible associated consequences – the author found it difficult to design an empirical study. A study of this nature would mean investigating the reality of the possible consequences for culturally diverse societies resulting from the relationship between the two discourses. These would have meant trying to look at individuals to investigate whether or not their understandings of cultural difference were being affected by the ideology of modern science. It is quite difficult to design such empirical studies as there are many different factors contributing to one's conceptualisation of cultural difference. Isolating the ideology of modern science as a single factor would be almost impossible. At the same time, in order to focus on individuals and their studies in science education it would have been necessary to analyse the presence of the ideology of modern science in science education in the first place. This latter aspect seems to the author of fundamental importance if empirical studies are to be developed in this field. This thesis concentrates on such an aspect. Empirical studies are considered as possible further research that can derive from this study, as it shall be discussed in Chapter 9.

1.2 Relevance and Innovating Character of the Study

Relevance of the Study

Several characteristics confer a particular relevance to this study. In the next paragraphs such characteristics are considered in detail. The first of them relates to the analysis of state science education in terms of its socialising potential. The study looks at science education as a societal defining and shaping tool used by the state. It focuses its attention on the political and socialising character that state science education can have.

This approach considers science education at the core of social, political and cultural interactions occurring between states, modern science and images of it and culturally diverse societies. It considers state science education as a linking means between states' understandings and demands from modern science with regards to cultural diversity, and the negotiating societal processes occurring between dominant and non-dominant groups. It looks at the nature of state science education in a context of cultural diversity, and in a context in which modern science is perceived as a cultural, economic and socially indispensable element.

Implicit in this approach is the development of an analysis on the nature, implications, and eventual outcomes of the relation between state education, science education, modern science and images of it, cultural diversity and maintenance of models of nation-state in Portugal and England and, more generally, in Western Europe. This analysis attempts to bring together three fundamental elements: modern science and images of it, state science education and nation-state cohesion. It involves an understanding of the role of modern science and of images of it, and state science education in nation and state formation and cohesion with possible associated consequences for cultural diversity.

The study is centred on Western Europe but it is more specifically focused on Portugal and England. The issues raised can be better discussed and analysed if centred on a particular context. Moreover, looking at Portugal and England the analyses in the study also highlight social and cultural differences and similarities between different EU states, and interacting relations between them.

The study tries to introduce new elements for the Western European educational academic debate regarding culturally diverse and science-oriented societies. It attempts to contribute to a social and cultural debate which, hopefully contributes for the future development of science education in ways that will participate in the construction of fairer culturally diverse and scientific societies. Societies in which citizens understand the role of modern science in their individual and group lives, and in which they can be active participants in political decisions that involve issues of cultural diversity and modern science.

Finally, and very importantly, the study attempts to contribute to the debate on the nature of intercultural science education. This debate is quite often disregarded, under the shape of educational developments oriented by remedial frameworks, derived from needs to deal with culturally diverse classrooms. Attention is given to cultural diversity in the classroom but not in the society, as if cultural diversity was an attachment to homogeneous societies. Moreover, intercultural education is seldom understood within a framework of education for all.

Innovating Elements of the Study

Associated with the present study are several innovating elements. One of those relates to the ways by which state science education is considered and looked at in the study: it is considered in terms of its political nature, and of its socialising role with regard to issues of cultural diversity.

State science education has been discussed and analysed concerning its political nature and socialising role in various ways. The proposal of science education for the development of scientific literacy (SL), and science education within a context of interaction between modern science, technology and societies (STS) is a result of such analyses[4]. These trends are mainly the outcome both of the recognition of the relation between modern science and societies, and the need to improve images of modern of science among the general public. Such trends are now very much oriented to issues of citizenship. However, they do not specifically deal with issues of cultural diversity.

In fact, although cultural diversity is a characteristic of contemporary societies, there is a strong tendency to ignore it in analyses that involve modern science, education and societies. This study presents an analysis of state science education that specifically deals with cultural diversity and the political and ideological ways by which states can perceive science education in and for such societies.

In order to develop this analysis, it was important to look at the ways by which education, Western European nation-states and modern science and discourse on it relate, considering cultural diversity as an interacting, continuously present-participant element. Cultural diversity has quite often been disregarded in such analyses due to the attribution of a neutral nature to scientific knowledge that posed it at a supra-cultural level in culturally diverse societies. Another innovating element characteristic of this study is then the discussions of the relation between state education, modern science and discourses of it and nation and state formation and cohesion in Western Europe, considering the political and ideological nature of scientific knowledge production.

The study is centred on Western Europe but as said earlier, it is focused in Portugal and England. Due to the recent nature of Portuguese concerns with cultural diversity there are as yet hardly any studies on education, cultural diversity and modern science in Portugal. Comparison studies involving Portugal and more experienced countries regarding means of dealing with issues of cultural diversity are thus of major importance. This kind of study may allow the development of new ideas as a result of a combination of experience and innovation. A comparison between Portugal and England is rather important if one considers the modernising process to which Portugal has been subjected and the possible influencing role of more developed countries of the EU.

A great deal of the work developed in relation to state science education and cultural diversity is classroom oriented. That is, developments occurred in order to promote better processes of teaching and learning modern science in culturally diverse classrooms. Most of them were designed in an attempt to decrease the number of students failing science subjects on account of their cultural origin[5]. However, these developments are generally associated with remedial strategies. It is hoped that this thesis will be able to present new elements for the future construction of possible frameworks for intercultural science education, which are based on deeper understandings of the nature of this subject. It is hoped that it will contribute to further discussions that will allow the development of better science education for everyone regardless of his/her cultural origin.

1.3 Structure of the Thesis

The thesis consists of this chapter and eight more chapters. Chapters 2, 3 and 4 constitute general analyses of education, including intercultural education, cultural diversity, nation-states and modern science and discourses on it within the Western European context. Chapter 5 defines the rationale for the comparative study, and establishes the link between the general analyses and those of Portugal and England. Chapters 6, 7 and 8 constitute the comparative study. Finally, Chapter 9 presents the concluding points of the whole study. The next paragraphs introduce each chapter in more detail.

Chapter 2 – *Cultural Diversity, Western European Nation-States, and Modern Science and Its Ideology* - consists of a general discussion within the Western European context of understandings of cultural difference, which developed along with processes of nation-state formation and maintenance. Particular attention is given to the role of modern science, specifically to a persistent ideology on it, in the development and definition of such understandings. The latter is seen as favouring dominant nations and the nation-state model, as well as their support of 'Western culture'. A historical perspective is taken, particularly focusing on the present. Arguments are made for the contemporary maintenance of such understandings of cultural difference. The discussion is not comprehensive and it derives from specific literature.

Chapter 3 focuses on state education, specifically science education – *State Education and Cultural Diversity: the case of science education.* The chapter discusses in a general form, within the Western European context, the development of state education. Particularly, it considers state political understandings of education, which rely on the construction of educational systems. Education for nation-state formation and maintenance is considered. The reflection in state education of the understandings of cultural difference put forward in the Chapter 2 is discussed. The case of science education is discussed in detail within a similar discussing framework. Attention is paid to the presence of the ideology of modern science in general state science education. An historical perspective is taken. Like in Chapter 2, the discussions in the chapter are not comprehensive and they derive from particular literature.

Intercultural education is discussed in Chapter 4 – *Intercultural Education: the case of science education.* Issues about models and practice of intercultural education in general, and intercultural science education in particular, are discussed. Reference is made to examples from Portugal and England. Aspects of the contemporary comprehension of the nature of intercultural science education are considered.

Chapter 5 – *Science Education, Cultural Diversity, and Modern Science and Its Ideology in Portugal and England: the study's rationale* – considers the analyses of the previous chapters and from them defines a rationale for a contextualised analysis of science education in Portugal and England. The latter refers to the educational presence and participation of the ideology of modern science in the promotion and transmission of understandings of cultural difference as considered in Chapter 2. The chapter puts forward the orienting comparative principles and research questions of the comparative study.

Chapter 6 – *Science Education, Cultural Diversity, and Modern Science and Its Ideology in Portugal* – comprises the study of the Portuguese case. It discusses the definition of the Portuguese nation-state regarding issues of modern science and cultural diversity. It considers Portuguese state education, referring also to intercultural education, and it analyses Portuguese compulsory science education. This analysis is centred on the participation of the ideology of modern science in science education and its role in the promotion and transmission of understandings of cultural difference. A detailed curricular analysis is made of compulsory curricula of physics, chemistry and biology. The chapter presents its results as answering elements to the posed research questions.

Chapter 7 – *Science Education, Cultural Diversity, and Modern Science and Its Ideology in England* – defines the study of the English case. It follows the same structure as Chapter 6.

Chapter 8 - *Comparative Analysis* - produces a comparison between the findings of Chapters 6 and 7, while analysing such results. The comparison is oriented by the comparison principles put forward in Chapter 5, and it defines a conclusion of the Portuguese and English studies.

Finally, the thesis ends with Chapter 9 – *Conclusion.* This chapter revisits the issues behind the development of the whole study. It discusses science education in general and the nature of intercultural science education. It poses new questions and suggests topics for further research.

Chapter 2

Cultural Diversity, Western European Nation-States, and Modern Science and Its Ideology

2.1 Introduction

This thesis aims to contribute to the debate on intercultural science education in Portugal and England and, hopefully, more generally, in Western European nation-states. Comprehending the participation of modern science and discourses on it in the formation of understandings of cultural difference is an important asset for the definition and development of intercultural science education. As it shall be discussed in this chapter, contemporary understandings of cultural difference tend to be related to the nature and evolution of nation-states. Consequently, comprehending the participation of modern science and discourses on it in the formation of understandings of cultural difference in Western European countries involves analyses of the relation between nation-states, cultural diversity and modern science (including its discourses). This chapter constitutes a contribution to such analyses. The discussions in the chapter are not comprehensive; frameworks on the nation-state and modern science, derived from specific literature (as considered in Chapter 1), support them. Moreover, particular attention will be paid to an ideology of modern science.

The chapter is divided into three main sections. These correspond to analytical discussions, often historically oriented, on:

- cultural diversity, understandings of cultural difference and processes of nation-state formation;
- modern science and the development of an ideology of it, with its respective characteristics; and
- the relation between the ideology of modern science and cultural diversity and possible social and cultural consequences.

So section 2.2 discusses in an historical and analytical manner aspects of the formation and development of the conceptual and 'real' Western European nation-state. The discussion focuses on understandings of cultural difference that developed in parallel with processes of state formation and evolution. Means of omission, exclusion and assimilation of culturally diverse groups are considered. Social, political and economic constructions of difference, as well as categories of inclusion and exclusion both within states, and between Western Europe and other parts of the world, are discussed.

The section argues that the understandings of cultural difference associated with nation-state formation and maintenance developed in ways that contributed to empower the nation-state's dominant group. It also argues that extensions of such understandings also contributed to empower Western Europe in relation to other parts of the world. As it will be discussed, nation-state and cultural diversity may be understood respectively, as the positive and negative sides of an opposing binary divide. This may be seen as a representation of a more general ideological binary comprehension of cultural difference. The latter seems to have been in operation between groups within states, and between Western Europe and other parts of the world. Within this perspective, state patriotism and nationalism were the main means of disseminating this ideology.

Arguments are also made that although de-constructions of binary understandings of difference have been occurring with demands for cultural recognition, the ways by which cultural difference is constructed tended to remain the same. Categories of 'us' and 'them' tend to be put forward. However, demands for political recognition have led at least to the visibility of all groups.

Section 2.3 discusses aspects of the nature and evolution of modern science both as a body of knowledge and as a means of understanding the natural world. The analyses in the section are also historically oriented. Particular attention is given to the establishment of an ideology of modern science. This is supported by the value attributed to scientific methodology and by the modern notion of progress. The relation between modern science and modern notions of truth and trust is discussed. The role of this ideology of modern science in reinforcing such notions is considered.

The section argues for the permanence and power of this ideology of modern science. This seems to have been the case in spite of changes occurring in terms of knowledge production, and in spite of all discussions around negative side effects of scientific and technological development. A discussion of the concept of sustainable development is considered so as to highlight the still present strength of such an ideology of modern science and its connection with political power. Although recognising the possible existence of other ideologies of modern science, due to the strength and persistence of this particular one, it will be referred in the whole thesis as *the ideology of modern science.*

Finally, section 2.4 discusses possible relations between the ideology of modern science and the understandings of cultural difference considered in section 2.2. It discusses the eventual role of the ideology of modern science in the promotion of particular means of understanding cultural difference as the real means of understanding of such a difference. It also considers ways by which such an ideology tends to be used to support an ideological and socio-economic comprehension of cultural diversity, which empowers dominant groups inside nation-states and 'Western' culture and ways of life in relation to those of other parts of the world.

2.2 Cultural Diversity, Understandings of Cultural Difference and Western European Nation-States

Although prior to modernity, cultural diversity has been a characteristic of the former. Yet it has persistently been omitted from modernity's narrative. One possible reason for this is acceptance, by the state and society, of specific understandings of cultural difference, which were developed so as to empower the nation-state and Western Europe. The comprehension of such frameworks cannot be set apart from the evolution of social and political forms of organisation in Western Europe, which culminated in contemporary nation-states. The next paragraphs explore such frameworks and their developments.

The Roots of Western European Nation-States

A great deal of discussion has been held regarding the reasons behind the rise and evolution of Western European nation-states both in conceptual and concrete terms[1]. In his historical essay 'What is a nation?', Ernest Renan (1882) considered the fundamental role of the Germanic invasions[2] for the future development of Western European nation-states. According to him, one of the outcomes of these invasions was the arising of dynasties, thus of families of political rulers. These families demanded groups of faithful people in order to sustain their political strength. They can be seen as having sowed the seeds for the development of processes of state formation.

Kennedy (1988) believes that Western Europe's political fragmentation, dynastically based and supported by the continent's geographical characteristics, was an important factor for the formation of the modern state. So was the case for war, as David Held (1995) sustains. War between various powerful dynastic groups defined a system in which empires could not survive. In spite of its enormous political strength, even the Habsburg Empire was internally ruled by a system of power partition associated with the characteristics of its spatial distribution. For example, from 1580 to 1688, Portugal was under Spanish occupation, thus constituting a part of the Habsburg Empire, but even so it still retained a great deal of independent administrative power (Kennedy, 1988).

The 1659 Spanish signature of the Treaty of the Pyrenees ended the possibility of the existence of empires within the limits of Western Europe. According to Davies (1997) and Kennedy (1988), by then, five or six major proto-states and many other smaller ones had already geographically established Europe's political plurality. The territories occupied by such states were the result of a century and a half of war. These states were differently characterised from previous feudal political and economic forms of organisation.

Sovereignty, War and Nation Formation

Several interrelated factors can be found in the transitional process from feudal frameworks of political organisation to modern ones. Those factors involved conceptions of a new territorial form of organisation, new means of production and trade, and new designs of group association. All of them seem to be directly related to the development of an independent and impersonal form of sovereignty. Western European absolutist regimes allowed its development at the same time that they resulted from it. According to Giddens (1985):

> The development of the European states begins to diverge from the pre-established pattern of the rise and fall of empires. This involves, above all, the formation of a new type of reflexively monitored state system, associated substantively and conceptually with the development of sovereignty. The conception of sovereignty, tied simultaneously to the position of the absolutist ruler and to the formation of a heightened bureaucratic centralism, is one of the most important elements binding the 'internal' development of the state with the 'external' solidifying of the state system. (Giddens, 1985, p.103)

Sovereignty was linked to land conquest and control. For that, powerful armies were needed, well equipped, and with new war techniques. New sources of money production had to develop along with new means of political attachment. A century and a half of wars, such as those waged in Western Europe from the sixteenth to the second half of the seventeenth century, demanded a constant supply of men and a constant supply of money. State bureaucratising developed in association with, for example, tax collecting. At the same time, control of the means of violence was demanded. As David Held (1995) sees it, all this was very important for the annihilation of dangerous loci of power within the state as well as for the control of the state's diverse population. However, control of the means of violence was not strong enough to establish internal state cohesion. The way to ensure that was by the creation of the nation. This was a process directly related to the cementing of sovereignty along with state democratisation. As Giddens (1985) puts it:

> The development of sovereignty, as concept and reality, is of major significance in relating what at first sight look to be quite opposed developments: the authority of the absolutist monarch and the coming of the modern democratic state. At the same time as the drive towards sovereignty generates a centralisation of resources in the hands of the ruler, it stimulates a generalised awareness that political power depends upon collective capabilities which the figure of the monarch may signify, but to which the traditional trappings of kingly rule have little relevance. (Giddens, 1985, p.198)

The legitimising of the state involved the end of internal warfare and the justification of external warfare. This implied the unification of the peoples living within the state's limits under a sovereign power. Democratisation was fundamental for that. According to Hobsbawm (1990)

> The very act of democratising politics, i.e. of turning subjects into citizens, tends to produce a populist consciousness which, seen in some lights, is hard to distinguish from a national, even a chauvinist, patriotism - for if 'the country' is in some way 'mine' then it is more readily seen as preferable to those of foreigners,

especially if these lack the rights and freedom of the true citizen. (Hobsbawm, 1990, p.88)

The transformation of state inhabitants into citizens was a very important means of state legitimising. However, this could only succeed if the attachment developed to the state was beyond the limits of politics. The way to do it was to associate state patriotism with nationalism, thus transforming citizens into nationals (Hobsbawm, 1990). From the original cultural attachments of the ruling political elite resulted an invented nation, to which state inhabitants were to be attached. Nationalism became in Hobsbawm's words 'the emotional centre part of state patriotism' (Hobsbawm, 1990, p.90).

The Nation and Cultural Diversity: 'Us' and 'Them'

Once more, according to Hobsbawm (1990), the creation of every nation involved particular ways of dealing with cultural diversity, mainly manifested by processes of group amalgamation and assimilation. Deriving from the cultural values of the minority group holding state power a national culture was invented. This was designed to serve the cultural demands of the new imagined community [in Anderson (1991) terms]. Consequently, so were new means of identification to serve those demands. Identification as a nation legitimised the movement from frontiers to borders, defined lines in a geographical map, which occurred from the eighteenth century onwards.

If one considers ethnicity to be an important distinctive element between groups, one can argue that, with the development of national groups, new ethnicities were created and others disappeared. In the understanding of Hobsbawm (1990), these new ethnicities however, were not understood as such but as national identities. Within such a framework, one can argue that national identities developed as unifying elements so that memories would become selective, processes of assimilation and group amalgamation would be justified and forgotten, and certain forms of power could be legitimised. Within the context of each state, it is plausible to consider that cultural diversity became implicitly perceived as a problematic aspect to be fought against. Such an understanding however, seems to have not been explicitly considered until the nineteenth century when aggressive forms of nationalism developed (Hobsbawm, 1990).

In this cadre, national identity formation operated as a way of introducing unifying elements that would distinguish nationals from non-nationals, and that would make those nationals proud of their condition of nation members. National identity formation developed by making use of a binary logical system of group differentiation.

Scholars such as Hall (1992) and Rattansi (1994) argue that national identities were created and developed within a framework of identification with two broad and general categories: those of 'us' and 'them'. The 'us' category involved those who belonged to a national group, and specific elements of attachment were considered. Among those, one finds language and religion, and later on 'race' and ethnicity. 'Them' were all those who were different from 'us' regardless of 'their' own specific characteristics. 'Us' was unified by similarity, and 'them' was unified by difference in relation to 'our' similarity.

In this context, each national identity could easily be associated with an 'us' category. The formation of each 'us' category can be seen as a continuous process dependent upon the ability of those defining the state for developing various unifying elements. This was the case for state efforts for language and religious singularising. British state unification and legitimising provides a good example of state definition of means of attachment, as analysed by Linda Colley (1992). According to her, the various groups occupying the British territory were driven to put aside their differences through an affiliation to a more important and broad category - that of religion. This category 'gave' people living in Britain a distinction from their 'common enemy': the Catholic French. This example highlights that constructions of 'us' categories were not only developed with the glorifying of nation. It supports Rattansi's (1994) argument that they made use of a binary and opposing logic of value classification, in which 'us' became equivalent to 'good', and 'them' became equivalent to 'bad' and 'evil' – the enemy.

This narrative of the nation was incorporated in another more complex one – that of the nation-state. In it, state and nation were ideologically associated. Conceptually, the nation-state constituted an ideal model, in the Weberian sense, of political and social organisation. Many late nineteenth and early twentieth century nationalisms represented this model mainly by the equivalence between 'soil and blood': 'one state – one nation' (Hobsbwam, 1990).

'Us' and 'the Rest'

Hall (1992) sees this nation-state model as embodying notions of monoculturalism and group homogenisation. It defined monocultural states, regardless of the different origins of many members. It considered an external category of homogeneous 'otherness', consequently not recognising external individual and group difference. The ideal nation-state was based on the binary system of identification represented by the categories 'us' and 'them'/'other'. It was thus intrinsically blind to multiculturalism. So was the case for the categories 'Western Europe'/'West' and 'the Rest' derived from the same system of classification (Hall, 1992).

Nineteenth century Western European nation-states were driven by imperialistic aims directed towards territories outside the European continent. As claims for territory ownership and control increased so did needs to deal with cultural diversity. These concerned not only inter-state fights for land possession, but also the necessity of justifying ways of dealing with the various indigenous populations now under European dominion and control. This had important outcomes in terms of Western Europe's self-conceptualisation.

Western European overseas expansion was the responsibility of a group of nation-states undergoing constant transformations. In time, for these, land ownership outside the limits of the European continent constituted an overseas extension of state borders. For those indigenous to such territories, it resulted in their subjection, control and exploitation. Overseas expansion meant Western European economic development. In the nineteenth century, it established this part of Europe as the most powerful economic and political area of the world.

Hall (1992) considers that economic development was not the only support of Western European empowerment. A narrative on Western Europe ideologically sustained it. The latter made use of the dual logical process of reasoning in relation to group identification and definition put forward before. Group definition among Western European nation-states was done in terms of the dichotomy 'us'/'them'. Colonialism allowed an extension of these groups. Western Europe became perceived as a big 'us' group in opposition to an entire broad 'them' – 'the Rest' (Hall, 1992) to be taken over.

It can be argued that a common European culture was created and promoted, as national cultures had been before. Within it, Europe was culturally isolated from the rest of the world. It was perceived as genuinely unique. As Bernal (1987) considers, historical influences from other cultures were omitted, even suppressed. Europe became identified with 'civilisation'. Ancient Greece became its birthplace. Multiculturalism was once more omitted, even if permanent nationalistically based fights were frequent in Europe.

The extension of the binary logical system of categorising and classifying to the broad categories of 'Western Europe' and 'the Rest' played an important role in cementing the binary understandings of cultural diversity. In general terms, cultural difference became understood in a dualistic manner, focusing on opposites. Considering the categories above, they involved a world division in terms of either white or black, either Christian or non-Christian, either civilised or non-civilised (Coulby and Jones, 1995, Hall, 1992, Rattansi, 1994).

Within Western Europe, this dual categorisation of 'us' and 'them' operated in ways such that the various 'us' groups became increasingly aware of 'others' both outside and inside their states' limits. These 'others', particularly those ones inside 'our' territorial limits, were often perceived as a menace to the state's stability. Consequently they were to either be assimilated or preferably, to be expelled. Late nineteenth and early twentieth century states thus promoted nationalism as never before, even if later on, they lost control over it as Hobsbawm (1990) notes. It was in this period that the framework of the model of the nation-state was set firm. Nationality and citizenship became ideologically equivalent. The nation demanded from its citizens an attachment defined by 'blood' or 'soil' or even, and preferably, by both. This equivalence legitimised processes of 'national' selection with dramatic outcomes. Examples of that can be seen in relation to the attitudes of the German State to German citizens of Jewish and Romani origin from 1933 onwards.

De-Constructing 'Us' and 'the Rest' – Cultural Diversity and Understandings of Cultural Difference Today

The outcome of the two world conflicts introduced new elements into the relation between nation-states and cultural diversity. At the state territorial level, the world map after World War II was different from that of the four previous decades. The conflict winners defined and imposed state limits that became accepted by those who had been involved (Hobsbawm, 1994). These limits however, did not necessarily constitute nation limits, and as time passed, several of them evolved once more as foci of tension and political instability, if not war. The disintegration of the Yugoslav State and the various outcomes of it constitute an extreme example of this.

At the level of international policy, a means of preventing, avoiding and controlling situations of xenophobia, racism and ethnic cleansing was seen as fundamental. The Nazi German attitudes towards cultural diversity exposed extremist attitudes towards cultural diversity occurring in Western Europe. International organisations such as the UN and those attached to it developed as a form of control and supervision of states' attitudes towards all their citizens. At the same time, the cultural nature of such citizens became not only increasingly diverse, but also and mostly the diversity became visible. The end of World War II brought to Western Europe many migrants after de-colonisation processes in Asia and Africa. Political changes within the continent produced the strengthening of groups who were previously politically disenfranchised. This was the case for example in Spain, where Catalans, Basques and Gallegos had been politically ignored in Franco's 'España Una' (one Spain – a united Spain).

The arrival and posterior settlement of new migrant communities forced a societal de-constructing of the original categories of 'us' and 'them', as well as those of 'Western Europe' and 'the Rest'. In fact, that of 'Western Europe' had already been transformed to another one - 'the West', via an ideological association between 'North American' and 'Western European' culture, societies and ways of life. After the political independence of most former Western European colonies, the political world could no longer be seen in terms of the two broad categories of 'the West' and 'the Rest'. 'The Rest' was no longer unified by its political dependency in relation to the 'West'. The cultural differences within 'the Rest' were manifested and recognised as new states were internationally accepted (Hall, 1992).

However politically independent, what was conceived as 'the Rest' is still quite economically dependent on the 'West'. As a result of this dependency an economic understanding of difference developed and two broad categories were put forward, those of 'developed countries' and 'developing countries'[3]. These categories are not exactly coincident with those of 'West' and 'Rest', and they are not necessarily presented in an opposing form. Nevertheless, their construction makes use of a binary system of understanding difference. Economy replaced culture as the classifying variable, and economic relations tend to empower what has constituted 'the West'. A great deal of the developed countries are geographically located in 'the West'. As a great deal of developing countries are geographically located in 'the Rest', many of which are attempting to follow political and economic 'Western' models. Countries such as Brazil and Mexico constitute good examples of that.

Cultural de-construction of 'the West' and 'the Rest' resulted in a multiplicity of other categories. Some of those derive from attachments to international organisations such as the EU, as just one example. Others are geographically defined, such as 'Scandinavia' or 'the Mediterranean'. Different variables define different forms of international attachment. However, in the basis of category definition are once more issues of similarity and difference regarding such a similarity. Each 'us' category has an associated 'them'. However, in many circumstances, contemporary politics forces acknowledgement of the variety within 'them'.

This is also the case within each nation-state. Migration to Western Europe increased the visibility of cultural diversity in Western European nation-states. Political de-construction of this variable was demanded as politics of recognition strengthened (Hall, 1992). The recognition of cultural diversity was demanded not only by the new settled communities in the states, but it was also requested by autochthonous groups which had been discriminated against by dominant nations. As such, and for example, the British State was not only forced to recognise its Muslim or Hindu communities, but it was also forced to allow the process of Scottish devolution.

As far as understandings of cultural difference are concerned, changes had to occur regarding the definition of 'us' and 'them' categories. Several 'us' categories were defined, as well as several 'them'. For each 'us', there exists a different 'them'. However, acknowledgement of the diversity of 'us' and 'them' is constantly demanded. The challenge to states and societies is thus the definition of forms of organisation that are inclusive of cultural diversity. So far ambiguity has been the main characteristic of political responses to this variable. Relations of power between intra-state nations influence state responses. Discourse and practice tend to diverge as cultural diversity is many times acknowledged by the first and omitted in the second. Characteristics of contemporary Western European societies are various forms of racism (skin colour, cultural and institutional racism), xenophobia and discrimination (cultural, skin colour and social and economic discrimination).

Contemporary understandings of cultural difference tend to be rooted in traditional binary means of comprehension. The increasing tendency to look at the world in terms of 'West' and 'Muslim world' reinforces this idea. Variable selection, category definition and classification processes tend to continue to define the means of understanding cultural difference. 'Us' and 'them' categories are still put forward many times in opposing terms. For each group of 'us' an opposing 'other' is defined. The nature of national and international contemporary settings however, forces an acknowledgement of group diversification. Every 'us' and every 'them' demands political recognition. It is plausible to argue then that the main difference between pre and post World War II Western European states in terms of understandings of cultural difference does not reside in the ways it is constructed; it resides in the visibility of cultural diversity. To put it differently, cultural difference tends to be conceptualised in the same way – groups are formed in the same manner. However, each group demands recognition, which leads to the visibility of all the groups.

This section discussed the development and evolution of means of understanding cultural diversity and constructing cultural difference. It considered that such means of understanding and construction were directly related to the rise and evolution of the Western European nation-state both in real and conceptual terms. The section argued that a binary system of understanding cultural difference was developed as states needed to promote internal cohesion. With that purpose, the idea of nation was introduced. The latter lay at the heart of the comprehension of cultural diversity as it defined one of the sides of the opposing binary divide defining cultural difference. Cultural diversity characterised the other side of the binary. As political and economic change occurred, so politics of recognition evolved. A de-constructing of the opposing binary categories of 'us' and 'them' was demanded. However, even if today, such a de-constructing has occurred and cultural diversity has become visible, processes of constructing cultural difference tend to remain the same.

While states and nations were being developed, modern science was also evolving. A great deal of Western European economic empowerment derived from scientific and technological development. Modern science was directly related to the development of Western European social, political and economic forms of organisation. One can then ask about the eventual participation of modern science in the processes of understanding and constructing cultural difference discussed in this section. Elements that may provide answers to this question are discussed in section 2.3.

2.3 Modern Science and Its Ideology

Section 2.2 discussed the development of specific understandings of cultural diversity and constructions of cultural difference in Western Europe. In order to discuss the eventual participation of modern science in the definition of such understandings and constructions it is important first to discuss some elements of the evolution of modern science. Once these elements are defined, analyses can be made of how they relate to issues of cultural diversity. This section thus discusses aspects of the nature and history of modern science. Specifically, it analyses the establishment of an ideological narrative on modern science, seen as based on the modern notion of progress and on the belief that modern science is beyond ideology. The survival of that ideology up to today is also considered.

Scientific Knowledge, Scientific Methodology, Truth and a Metanarrative on the Natural World

The seventeenth century Scientific Revolution brought with it a synthesis of existing knowledge about the physical world. It represented a culminating point of a long process of philosophical and academic change occurring in Western Europe. As Redondi (1990) considers, this was developed both in relation to the understanding of natural phenomena and with regard to the comprehension of knowledge itself. Men like Galileo, Descartes, Bacon, and Newton contributed to the process. It became mainly represented by the consolidation of physics as a structured body of knowledge obtaining, which was defined and supported by use of a particular methodology when inquiring about the characteristics of the natural world (Redondi, 1990).

Prior to the Newtonian Revolution, elements of natural philosophy, cosmology, metaphysics and magic constituted a diverse and fragmentary, although interrelated, group of answers to questions about nature. In fact, according to Hall (1962) and Redondi (1990), the seventeenth century knowledge synthesis shaped and chose those and other answers by making use of the following beliefs: a) the existence of an explaining metanarrative about the natural world; and b) the existence of a particular method of inquiry on the physical world capable of providing such explanations. Underneath these beliefs lay a more general one on the possibility of finding the truth. Men like Descartes and Bacon were inspired by an 'optimistic epistemology' in Popper's words (1963, p.5) based on the idea of the liberating nature of truth. For these men, as Popper put it:

> Truth may perhaps be veiled. But it may reveal itself. And if it does not reveal itself, it may be revealed by us. Removing the veil may not be easy. But once the naked truth stands revealed before our eyes, we have the power to see it, to distinguish it from falsehood, and to know that it is truth. (Popper, 1963, p.5)

The role of modern science was to reveal such truth. The concept of truth is a characteristic of the Enlightenment mind-set. In this perspective, modern science constituted an outcome and supporter of this order (Popper, 1963). The belief in metanarratives is also an Enlightenment characteristic. Physics as a structured, mechanistic and objective body of knowledge, capable of explaining and predicting natural phenomena, became perceived as the metanarrative for the comprehension of the natural world (Hall, 1962, Popper, 1963). In Hall's words, 'mathematical physics was not merely a formal structure. It was an actual description of the real world'. (Hall, 1962, p.371)

The Possibilities of the Scientific Methodology, Progress and Trust

The importance attributed to such a metanarrative can be seen as contributing to promotion of its extension beyond the limits of nature's understanding. The idea of owning a methodology that was objectively capable of providing the truth about the natural world was one of empowerment. With such a methodology, Western European scientists could then feel that they were given the possibility of understanding the laws that ruled the complex mechanism, which God had created as the universe. Again according to Hall, Christianity furnished the scientist with God as the First Cause of things. But if this First Cause had, so to speak, set the universe to run its course and endowed man with free-will to make his own destiny, the phenomena of nature could only be the result of determined processes, manifestations of a mechanistic design, like an infinitely complex automaton clock. (Hall, 1963, p.xvii)

So, not only was seen understanding possible, but also that was the case for prediction of a new phenomenon and of the evolution of phenomena already explained. With such methodology, knowing, comprehending and controlling the natural world were admitted (Trigg, 1993). Intrinsic to human ownership of scientific methodology tends to be the idea that humans were then closer to God and thus more powerful and confident.

This powerfulness can be seen also as a result from the free development of ideas associated with modern science. Since the scientist and the politician were quite often the same individual, indirectly, modern science played a basic role in the development of the Dual Revolution[4] as Habermas (1971) and Popper (1963) noted. The latter was basic for the cementing of a new economic order and its demands promoted modern science's own evolution (Hobsbawm, 1962, 1975).

The input given by the Dual Revolution to the development of modern science can be seen as involving two important aspects with major consequences on time. On the one hand, it promoted the continuation of the development of new scientific ideas. Some of which were later on applied to fields other than the natural world, introducing thus an extension of the concept of modern science as Porter (1990a) considers. On the other hand, and according to Habermas (1971) and Hobsbawm (1962) the Dual Revolution was decisive for the acknowledgement of the importance of a direct relation between scientific knowledge and technological production.

Most technological developments brought about by the Industrial Revolution found their roots outside the academic environment. As noted by Green (1990), modern science was by then still very much attached to natural philosophy, and the understanding of its practical potential via technology was not immediately perceived. When this perception occurred, it implied emphasis on scientific production. The increased scientific and technological production along with the economic outcome of the Industrial Revolution produced a sense of wealth and social and economic growth in the societies (Hobsbawm, 1962, 1975). This could encourage the development of the modern notion of progress.

Progress was a very important idea to the Enlightenment as Coulby and Jones (1995) note. The technological innovation brought about by the Industrial Revolution, associated with new political individual and collective demands put forward by the French Revolution, made such progress seem possible, and in many cases, visible as Hobsbawm (1962, 1975) has pointed out. Modern science can be seen as a supporter of the construction of this notion of progress. It was the basis of technological development, as technology and scientific knowledge became increasingly associated. Such a belief in the value of modern science can be seen at the inner core of a process of movement from a human conviction in faith to one of confidence, associated with increasing state secularisation. Modern science appeared thus of great importance for the construction of what Giddens (1990) defined as trust, a characteristic of the modern secular and rational order. One can argue that trust in modern science became a substitute for faith in religion.

The changing processes occurring in Western European societies after the Dual Revolution, both at the economic and political level, implied a set of social changes. These changes varied from the development of new forms of socio-political organisation to the implementation of new ways of living (Hobsbawm, 1962, 1975). Economic progress implied development of the notion of social progress. As Porter (1990b) argues, in practical terms modern science and technology were understood as a means for improving the human condition. Examples of that can be seen in the increasing participation of modern science associated with technique in urbanisation processes, and in the attention given to the development of routines of individual diet and hygiene. The latter one is strongly emphasised by state science education, according to Jenkins (1981) studies. In fact, the whole introduction of modern science in state curricula, mainly through technical education, can be seen as an example of what has been said[5] (see Green, 1990, 1995).

Modern Science and Politics – Ideologising Modern Science

However, social progress was not the only connecting means between modern science and the social world. According to Halmiton (1992) and Porter, (1990a), an understanding of scientific methodology as unlimited in its possibilities, in combination with the political desire for removal of power from the Church, were basic for the development of the idea of applying such methodology to fields other than the natural world. Examples of that can be seen in some of the original economic theories of capitalism, as well as in other applications of the scientific method to understandings of individual and collective behaviours, culminating in Marx's synthesis on the social sciences as Porter (1990a) suggests.

The extension of the dominion of application of scientific methodology can be understood as having various implications both for modern science and for societies. On the one hand, it provoked a broadening of the concept of modern science. What had originally been constructed as a means of knowledge on and understanding of the natural world, was extended to involve non-natural processes and phenomena associated with human behaviour. On the other hand, it stressed the value of the scientific methodology as the means for knowing the truth not just in relation to the natural world, but also in relation to the human one. That is, it emphasised the idea of the scientific methodology as *the* methodology for obtaining the truth, and it then made of scientific knowledge a and *the* superior form of human knowledge as Hodge and Cantor (1990) note. Consequently, as confidence - in Giddens' sense (1990) - had replaced faith, so modern science was on its way to operate as a substitute for religion (Brooke, 1990). Modern science could became therewith confirmed as a fundamental basis of the modern order. For that, and in the views of Brooke (1990) and Trigg (1993), an important role was played by the positivistic obsession for separating scientific knowledge from philosophy and for emphasising the power of reason expressed in and through modern science.

Enlightenment thinkers such as Bacon and Descartes had defended the value and power of knowledge. The extension of the dominion of modern science to the non-natural world, in association with the comprehension of scientific knowledge as the rational, positivistic knowledge, along with the new scientific and technological developments, can be seen as contributing to the consolidation of the understanding of modern science as an element of power. Once the scientist was quite often the politician as well, and according to Outram (1990), from the end of the nineteenth century, beginning of the twentieth century onwards, modern science became an essential form of political power. This political empowerment cannot be divorced from the socio-political changes that were occurring in those days. One can argue that such socio-political conditions were fundamental for, and were in need of, an ideologising of modern science.

As Outram (1990) notes, modern science could work as support and justification for state secularisation, colonial exploitation, societal stratification, and economic organisation. The extension of the concept of evolution to the social world, theories of 'race' and eugenics, along with the rationalisation of both the means of production and social organisation for the pursuit of progress constituted a perfect basis for a particular societal model. This was characterised by secularism, oriented by reason and made racially and economically superior by modern science's findings and achievements, quite often presented in technological terms. Following Outram (1990) and Porter (1990b), supporting such a model was an ideology of modern science that was founded on the absolute validity of the scientific methodology as the means to find the truth. The message transmitted by this ideology was that, precisely due to such methodological characteristics, not only was scientific knowledge *the* knowledge, but also modern science itself was beyond ideology.

The combination of this ideological narrative of modern science and scientific and technological development decisively reinforced the intricate relation between modern science and states. The role originally occupied by religion in state organisation and, one can even argue, in ruling, was perceived by some, like Brooke (1990) and Feyerabend (1978), as being then occupied by modern science. Moreover, the acceptance of modern science as beyond ideology could allow its uses as a means of obtaining 'neutral' solutions for problems eventually to be politically discussed and solved (Porter, 1990b). As Porter (1990b) comments while discussing aspects of contemporary modern science:

> Over the centuries, in scores of contexts, natural science pronounced freely upon issues such as race, gender, normal sexuality, the healthy mind, and man's place in nature. This has occurred so commonly that it is implausible to speak of such instances as mere 'abuses' of science: they have been integral to its uses. (...) As powerful schools of scholarship over the last decades have argued, science was able to act as an ideological mouthpiece in this way because the 'objectivity' and fact/value distinction on which it was built gave it the promise of being beyond ideology. (Porter, 1990b, p.41)

Such an ideology implied the embodiment of modern science in democratic and liberal processes as Feyerabend (1978) and Habermas (1971) noted.

Years of Glory

From the late nineteenth century until the end of World War II, modern science experienced its most significant days as the 'untouchable', absolute form of knowledge production and as *the* knowledge. Such a status was supported by constant scientific and technological evolution and by positivist confidence in the value of scientific methodology, according to scholars such as Hobsbawm (1987, 1994) and Hodge and Cantor (1990). Both aspects were supported by the ideology of modern science as previously mentioned. As it will be argued in the next paragraphs that ideology has been maintained until today.

The beginning of the twentieth century witnessed important developments in the production of scientific knowledge, most dramatically in relation to physics. Those developments were mainly expressed by Einstein's relativity theory and by quantum mechanics. With them, not only did scientific knowledge on the natural world evolve in unpredictable directions, but also such an evolving implied new philosophical understandings of basic elements within the production of scientific knowledge itself. Fundamental ideas such as those of reality, truth, objectivity and universality suffered important re-formulations in physics.

This evolution in physics was of extreme importance for modern science. New possibilities of knowledge in relation to the natural world were found as well as new applications for them. Once more, this evolution promoted human empowerment. Modern science, with the endless possibilities of understanding and controlling nature, which culminated in the fabrication of the atomic bomb, was, as never before, involved in human empowerment (Hobsbawm, 1994).

Challenges to Modern Science

As more and new scientific knowledge was produced, more new and important challenges were put to modern science. Understanding modern science within a philosophical framework became increasingly important. Philosophers of science, such as Popper and Kuhn, posed fundamental questions about an intellectual activity that until then had hardly been under scrutiny and analysis. The original ideas of truth, absolute validity, objectivity and universality attached to the means of scientific knowledge production were discussed not only in philosophical terms but also in sociological ones. Radical philosophers such as Paul Feyerabend (1992) contested the whole existence of a single scientific method.

The aftermath of World War II, particularly the results of the use of the atomic bomb and nuclear energy introduced other elements of discussion into the constructed concept of modern science. Such elements were reinforced in time with the increasing visibility of the destructive power of various scientific results expressed for example in war situations or in environmental disasters. More recently, fears have been expressed about the development of genetics.

Not only questioning the nature of modern science, these elements also questioned the modern idea of progress. Scientific development, mainly made visible through technology, had been generally associated with the belief in pursuing a neutral and universally positive improvement of the human condition (Coulby and Jones, 1995). Several results of such development expressed, for example, through mass killing such as that produced by atomic bombing, industrial environmental destruction, and health risks obtained out of the use of atomic energy made clear the complexity of the 'neutral' and 'positive' nature of progress. Consequently, this concept was vigorously contested and modern science, regarded in terms of the natural sciences, became feared even by some of its producers (Hobsbawm, 1994).

The implications of such civil, social and political discussions on modern science produced an important lack of faith in it. This aspect can be understood as a responsible element for the shaking of the very modern concept of trust, which indirectly depended on the well functioning of various modern science products understood as rationally organised systems.

During the third quarter of the twentieth century, other developments occurred within knowledge production and understanding that would stress even more cogently the development of such a loss of faith in modern science. Almost in a parallel way to the explicit civil, political, and social discussion on the natural sciences, the social sciences reflected the change of paradigm occurring already within the natural sciences. Intellectual movements such as post-structuralism and post-modernism reflected such paradigm change and questioned the very nature of knowledge and its production at the level of the inquiry on the social world.

The Power of the Ideology of Modern Science

In order to diminish the emphasis on the problems raised by scientific development, one can argue that contemporary discourses and practices in relation to modern science have attempted to separate scientific knowledge from its uses. In the latter it seems to be recognised that there is an intricate relation between modern science, societies and political and economic power. However, arguments are persistently made stressing the impossibility of contemporary ways of living without modern science and technology and on the possibilities of modern science for finding the truth as Hobsbawm (1994) and Lowe (1998) note.

During the years of the post-world war period, even natural scientists considered the possibilities of modern science with fear. Such fear seems, nevertheless, to have been compensated for by the political and ideological definition of a separating line between scientific knowledge and its uses. The idea of fearing modern science tended to be redirected towards fearing several of its political and social uses. A similar situation can be seen occurring today in relation to the development of genetics. Emphasis has been put on the civil, social and political control of scientific production and use of scientific results. Development of educational trends such as Education on Science, Technology and Society, and Scientific Literacy represent these concerns (Solomon, 1993, Goldsmith, 1994).

Regardless of all the discussions around modern science, persistence in the ideology of modern science is quite often found in contemporary societies. A great deal of the arguments that have been made relate to the relation between modern science and the concept of progress. The responses to such arguments can be taken as an important example of the maintenance of the ideological narrative of modern science which was put forward in this section.

A great deal of the contesting movements in scientific development found their roots in environmental concerns. These relate not only to present situations but also to the well-being of future generations. The introduction of the concept of sustainable development as a substitute for indiscriminate progress was the international response to the 'environmental crisis'. The 1987 report 'Our Common Future' from the World Commission on Environment defined sustainable development as follows:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (...) It contains two key concepts: - 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; - the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs. (World Commission on Environment, 1987, p.43)

This concept replaces the notion of progress with that of development. It associates development with the environment and it is inclusive of 'the world's poor'. However, it does not deny the importance of modern science for such a development, nor to find the truth. In fact, as Lash et al (1996) argue, modern science has been perceived as necessary for sustainable development. According to them,

> The translation of things 'environmental' into authoritative scientific and policy vocabularies occurs in ways which could be described as, amongst other things, epistemologically 'realist', positivistic, disembedded, technological and cognitivist. (...) This is all more serious because widespread public concern over the effects of human activity on the natural world has produced a broad consensus between scientists, policymakers and other 'authoritative' commentators about the need for more reliable information about the present condition of the environment, the status of current threats, and the imperative for appropriate responses. From such a consensus has emerged a number of large-scale intergovernmental research programmes, global conventions and national

> policy commitments, all too often oriented around overwhelmingly realist accounts of the environment. Even the social sciences, in their embryonic grapplings with the environmental agenda, have hitherto largely proceeded uncritically on the basis that the environment exists simply as a material substrate of the social, defined by scientific enquiry. (pp.1-2)

Lash et al (1996) argue that the environment has been understood within a traditional modern science framework. Sustainable development has been associated with planning, prediction and control within the cadre of the ideology of modern science as the provider of truth. Indeed, the modern concept of progress was contested and so was the role of modern science in it. However, the concept of modern science has remained mainly the same. So has been the interaction between modern science and states supported by this same ideology. Sociologists of science such as Fuller (2000) argue for the need of a second state secularisation: in this case that of modern science. Increasingly one finds a state dependency on scientific knowledge and expertise. Scientists are called for advising on almost all areas of society. For example, one of the aims of contemporary Portuguese science policy is the increase of participation of scientific expertise in decision-making (see for example Governo, 1999). At the bottom of these political attitudes one can find the idea of modern science as beyond ideology.

With the association between sustainable development and modern science the latter's ideology tends to be maintained. With state dependency on scientific knowledge and expertise, modern science is persistently involved in political, social and economic issues, thus maintaining its image as existing beyond ideology. One can argue that regardless of change, modern science exists in contemporary societies quite often embodied in an ideological narrative on it, which is rooted in the nineteenth century ideological syntheses on knowledge production and social and political forms of organisation. Understanding contemporary modern science cannot be set apart from understanding its ideology. The analyses in this thesis particularly consider this ideology.

This section discussed the development of modern science. It considered the importance of the following elements in this process:

- seventeenth century changes on understandings of knowledge and knowledge production;
- the nineteenth century synthesis on the nature and implications of scientific knowledge; and
- twentieth century scientific and technological developments and their consequences.

The section focused on the construction of an ideological narrative on modern science which tends to persist until today. In this narrative modern science is understood as beyond ideology, thus being capable of providing truthful answers about the natural and social words. Such ability is seen as deriving from the nature of scientific methodology and from the modern acceptance of the existence of truth. Within this ideology modern science is perceived as fundamental for human evolving, contemporarily defined in terms of sustainable development. Trust in scientific knowledge, associated with modern science's ideology, has been seen to be basic for the relation between modern science and states. It has been argued that modern science tends to occupy much of the role previously occupied by religion.

In section 2.2 particular understandings of cultural diversity and constructions of cultural difference were put forward. These were discussed according to their relation with state and nation formation. In this section it was argued that modern science holds a special relation with the state, supported by its ideology. One can then ask about eventual uses of such an ideology in the definition of such understandings of cultural diversity and constructions of cultural difference. A discussion on this issue is the object of the next section.

2.4 Cultural Diversity and the Ideology of Modern Science

Section 2.2 discussed the formation of specific understandings of cultural difference, which could be seen to be present in Western European societies until today. Such understandings tend to be found in the basis of states' means of dealing with cultural diversity in such societies. Section 2.3 discussed the evolving of modern science in Western Europe. Particularly, it considered the establishment of an ideology of modern science, which has been dominant from Newton and Kant until today. This section discusses the possible participation of this ideology in the formation of the understandings of cultural difference considered in section 2.2 and several of the eventual associated implications for non-dominant groups. The following elements will be specifically considered:

- the possible role of the ideology of modern science as a means of legitimating Western European understandings of cultural difference as *the* understandings of cultural difference; and
- the possible role of the ideology of modern science in a continuous cultural and political empowerment of Western Europe by supporting particular ideological and economic constructions of cultural difference.

Categorisation and Classification as the Means to Understand Cultural Difference

The ideology of modern science can be seen as inherently supporting the idea that processes of variable selection, classification and categorisation are *the* means to understand cultural difference as it shall be discussed.

The characteristics attributed by the ideology of modern science to scientific knowledge and to the scientific methodology constructed modern science as the paradigm of rationality, as Briskman (1990) notes. Within such a framework, *true* and *unique* knowledge about reality is understood to be the result of modern science. In other words, scientific knowledge constitutes the truth; other knowledge is easily considered false. Rational knowledge tends to be framed within a value given binary means of comprehension in which no multiple true answers are generally accepted or even considered to be possible. A selection of one side of the binary implies the acceptance of a position in terms of either/or, right or wrong - true or false.

The establishment of categories of cultural diversity through processes of variable selection and classification, as is the case for the 'us' and 'them' categories, can be seen as a process of data organisation and interpretation, based on the scientific methodology. The ideologically superior value generally attributed to scientific means of reasoning can inherently support such processes as *the* means for comprehending cultural diversity. In this perspective, Western European means of understanding cultural diversity are easily accepted as the truth and all other means are generally taken as a false.

Each category of diversity is mainly defined by a variable. If this variable is scientifically obtained or justified it can make such a category value-free, if modern science is considered beyond ideology. For example, for a long time 'race', which was perceived as an important variable for understanding cultural diversity, was 'scientifically' defined with the support of eugenics and social Darwinism. The 'race' category could thus be considered to be value-free. So was the case for other categories such as that of nationhood, for a long time often related to 'race'. Moreover, the ideology of modern science could then be capable of supporting the development of this category within the framework of an ideological construction of cultural difference in which culture and biology were associated.

The Ideology of Modern Science and Ideological Constructions of Cultural Difference

The ideological construction of nationhood tended to involve the scientific ascertaining of the association of specific biological characteristics to a group characterised by a particular culture. A basic societal outcome of this was scientific racism.

From the late nineteenth century onwards, and under the umbrella of the term 'scientific', a great many studies were carried out, and a lot of theories on individuals and their characteristics was put forward (Hobsbawm, 1975). Different cultural groups were studied so as to establish their 'common' biological characteristics. This was part of the object of disciplines such as eugenics and social Darwinism. Within this framework, nationals of a state could be defined excluding state citizens of different cultures. It was perceived as the perfect support for the nation-state model in terms of the pursued equivalence 'one nation – one state'. In practical terms, the extreme result of this ideological construction of cultural diversity occurred in Nazi Germany with the treatment given by the German State to German citizens of Jewish or Romani origin.

However, scientific racism was also applied outside nation-states borders. It tended to be used to empower Western Europe by justifying colonial imperialism. Social Darwinism and eugenics were important in this process, often in association with the notion of progress. Modern science was the provider of progress and the ultimate application of rationality. Consequently, Western Europe, where it was developed, could be understood as 'civilisation'. These ideas contributed to the establishment of a 'scientific' hierarchy of 'races'/cultures. In its basis could be found the notion of evolutionary human progress, which resulted from an association between progress and history, as Hobsbawm (1975) notes. Dominion and exploitation, expressed by colonial imperialism, could be justified.

The post-war condemnation of the extreme racist attitudes of Nazi Germany produced important reactions against scientific racism. The latter became discredited along with eugenics and social Darwinism. The label 'scientific' was removed from the knowledge produced by scientific racists. It was categorised as ideological. The scientific nature of the methods of study used and of the knowledge thus obtained was vigorously contested. New understandings of the nature of these disciplines characterised them as non-scientific and consequently, their bodies of knowledge were disregarded as truth. The same ideology of modern science that had stamped the label of science on social Darwinism and eugenics was justifying its removal, and serving again the political and ideological needs of the states, which had changed. In fact, biology was now ascertaining the non-scientific importance of the concept of 'race'.

As scientific racism found support in modern science's ideology so it seems to be the case for cultural racism. Examples of this can be seen in the persistence of nature/nurture debates expressed in books such as *The Bell Curve* by Herrnstein and Murray (1994). An interest in correlating social characteristics with genetic ones has been promoted by the continuing development of fields such as sociobiology. *The Darwin Wars* (Brown, 1999) is a book from 1999, which attempts to present sociobiology within a neutral frame. It relates to some old ideas on the comprehension of difference among human beings, which were behind disciplines like eugenics. It constitutes an important representative of the insistence on scientifically justifying difference. But maybe the best example comes from genetics. Many geneticists look for genes to explain, if not justify, psychopathic or homosexual behaviour, among others.

In fact, it was genetics which de-constructed the concept of 'race'. The ideology of modern science once more supported such de-construction as the truth. However, progress and modern science's nature as beyond ideology can also be found supporting genetic engineering development.

Genetics is one of the most important branches of modern science in contemporary societies. At the same time, it is probably the body of knowledge that more clearly expresses the dangerous potential of the relation between modern science and societies concerning cultural diversity. Contemporary genetics can provide means of interference in processes of human selection. It can support associations between biological elements and cultural and intellectual behaviour according to pre-defined variables of diversity. It can also promote new forms of discrimination. The use of genetic testing in the definition of life insurance values, by many insurance companies in Western Europe, is already an example of that.

This example reflects the power of the ideology of modern science in various ways. It involves the idea of trust in modern science and the possibilities of the latter as provider of truth. Yet, in reality, genetic testing, for example regarding breast cancer, does not reliably predict the future development of the disease. It provides a probability for such a future development. The disease may not occur. Individuals may be discriminated in terms of a category to which they do not belong. The ideology of modern science can, in this case, directly contribute to the formation of categories, which are generally perceived value-free, but which, in reality, can be discriminating.

This is only one example. Many others can be discussed, such as those relating to possibilities of cloning or of changing the characteristics of future human beings. However, more important to the discussion are the ways by which states and societies tend to deal with the possibilities opened up by genetics. Great emphasis has been given to ethical issues and to their relation with modern science. This is an important centre of discussion. However, it tends to lack a fundamental discussion of the ideology of modern science. Modern science as beyond ideology is usually not contested. What is considered to be at stake are uses of modern science, not its ability to provide answers or to directly interfere in political matters. Ethics is often asked to solve new moral dilemmas, which are assumed to derive naturally from scientific development. Issues on the nature of the production of knowledge and on its relation with states and in power groups are generally not considered[6]. The ideology of modern science, once more, seems to obscure this relation. This is also possibly the case regarding the ways in which socio-economic images of cultural difference are constructed.

Progress, Sustainable Development, the 'West' and 'the Rest'

Parallel to ideological constructions of difference, Western European nation-states developed socio-economic constructions of difference. Such constructions tended to mainly involve the economic empowerment of the 'West' and its association with its own cultural superiority. The latter was generally understood in a direct relation to ownership and development of modern science. Modern science was/is considered as the basic element for both progress and/or sustainable development. Uses of the ideology of modern science may be seen in the promotion of discriminating developments of progress/sustainable development.

A great deal of modern science's participation in Western European socio-economic constructions of difference was made by omission. Social and economic progress was quite often defined according to the needs of certain groups, which were generally detached from the 'rest' due to their specific superior characteristics. Progress was implicitly destined and designed for white, male and upper class individuals. Results from such progress very seldom reached the majority of the population. Within a similar framework, the same was the case in relation to the colonies. A great deal of the scientific knowledge produced regarding the colonies was directly related to colonial exploitation, in terms of agriculture and industry, disregarding most of the needs of the autochthonous populations. This had important future consequences regarding the developing of all new countries after de-colonisation.

De-colonisation presented the world with a set of countries with a great many social and economic difficulties. The lack of progress/development of the new countries could easily be used to perpetuate images of cultural inferiority of their populations. Moreover, lack of scientific development in these countries contributed to the maintenance of their economic dependence on the 'West'. These countries are now asked and demanded to pursue sustainable development. Yet, it is still the 'West' that mainly defines the characteristics of such development.

Within Western Europe, scientific evolution tends to follow particular lines that can support the persistence of certain forms of difference. Choice for the location of industries in less empowered communities involving health risks; the allocation of different scientific jobs according to cultural differences; the development of the pharmaceutical industry in accordance to lobbies of power; all these constitute contemporary examples of what has been discussed.

Contemporary scientific development cannot be seen apart from that of economic development. Moreover, neo-liberalism supports the importance of market forces and competitiveness for the development of scientific creativity. In an editorial of the magazine *The Economist*, it is argued that it was the competitive element introduced by the private company Celera Genomics that promoted the increasing development of new discoveries within human genetics (The Economist, 2001b). This company was created as a means of profit mainly defined by its association to the pharmaceutical industry. On the other hand, the 2001 Oxfam report on Third World countries and medical needs highlighted the difficulty of such countries' populations in obtaining basic drugs (The Economist, 2001a). Economic competitiveness may introduce changes in the speed of scientific knowledge production. However, it can direct such production to the satisfaction of the needs and demands of those in power. Ultimately, it can continue to support, possibly even in a stronger form, economic and social constructions of difference that deny democratic access to *sustainable progress*.

This section considered ways by which the ideology of modern science can participate in understandings of cultural difference with associated consequences regarding cultural diversity in general. It was suggested that the ideology of modern science can support 'Western' means of understanding cultural difference as *the* means of understanding such difference. It was also suggested that the ideology of modern science seems to have been defining categories of cultural diversity as if they were culture-free. Most of these categories however, involve discriminating elements. The generation of new categories of diversity after the latest developments in genetics, with associated implications for particular groups, was also considered.

Sustainable development and progress have quite often been operating within non-democratic frameworks which discriminate against particular groups. Both progress and sustainable development tend to be defined within the framework of the ideology of modern science. Within such a framework, they constitute a means of further economic as well as cultural empowering of the 'West'. By geographically limiting such progress/sustainable development to particular areas of the globe, economic development deriving from scientific evolution has supported, even increased economic differences. These contribute to maintain the power status quo as well as cultural hierarchies.

2.5 Conclusion

This chapter discussed aspects of the relation between cultural diversity, Western European nation-states and modern science and its ideology. It started the discussion by analysing means of understanding cultural difference in Western Europe. Their origin was seen in the dependency of the development of states and nations. The bases of these means seem to have been processes of variable selection, classification and the definition of categories. A binary understanding of difference has been also basic. Such a comprehension of cultural difference tended to be maintained until today even though politics of recognition have promoted de-constructions of categories of diversity. The strength of such maintenance may be seen in an implicit support of modern science, via its ideology, of the means of understanding cultural difference.

The ideology of modern science has been an important ally to Western European nation-states since it can contribute to their economic and cultural empowerment. This empowerment was quite explicit regarding issues of imperialism and colonial exploitation. Today, it still seems to support relations of economic dependence of 'others' and the 'West'. It also seems to support the cultural supremacy of the 'West' via its continuous development of modern science and technology. Moreover, the ideology of modern science can be seen as a very important supporter of the idea that 'Western' means of understanding cultural difference constitute *the* truth. This is so as these means involve processes of reasoning associated with scientific methodology. In all these respects modern science, via its ideology, can be understood as a powerful tool for states' justification of means of dealing with cultural diversity.

The permanence of the ideology of modern science was strongly argued. However, no reference was made to means of spreading and promoting such an ideology. There may be many different ways of doing this. One of those is state education. It has been an important tool in state and nation formation and it is seen as fundamental for scientific and technological development. One can then question the role of state education regarding issues of cultural diversity, understandings of cultural difference, the ideology of modern science with respect to the former two. A discussion on these issues is initiated in the next chapter.

Chapter 3

State Education and Cultural Diversity: the case of Science Education

3.1 Introduction

This chapter discusses the role and participation of state education, particularly, science education, in state means of dealing with cultural diversity. The discussion is historically oriented and it makes use of examples mainly from Portugal and England.

The chapter consists of two main sections. The first section refers to state education in general and its relation with cultural diversity. It involves analyses of how states developed educational systems according to their needs, in terms of nation and state formation and cohesion. Immediate consequences for cultural diversity are put forward. These were reflected in the ways by which education was designed for particular groups, omitting some and attempting to culturally assimilate others. Issues of social control, social mobility control, economic development, individual development, exclusion and neglect are discussed along with models of education, focusing on cultural diversity. Finally, a discussion is developed regarding contemporary state means of dealing with cultural diversity in education. These result from demands for recognition and state attempts to maintain the political and cultural status quo. Among those means, attention is paid to processes of segregation, separation and naturalisation occurring in educational systems such as those of Portugal and England.

Science education is part of contemporary state education. Consequently, it is embodied in general state understandings of education and cultural diversity. These constitute the object of the other discussions in this chapter. They involve the analysis of the introduction of science education in state education curricula, focusing on issues of aims and provision. They also consider the aims which were put forward for science education. In analyses of those aims, a discussion is held of their importance for nation and state cohesion and their implications for cultural diversity. Arguments are made for the contribution of science education towards discrimination in terms of social class, gender and cultural diversity.

Analyses of the socialising rôle of present science education in countries such as Portugal and England are put forward along with their possible implications for understandings of cultural diversity and educational means of dealing with it.

3.2 State Education and Cultural Diversity

The development and expansion of state education in Western Europe is a characteristic of the nineteenth century. According to Barreto (1996) and Green (1990, 1995), it largely occurred in a parallel way to the establishing of nations and states. Moreover, as Green (1990, 1995) and Hobsbawm (1990) have argued, the development of most Western European state education systems occurred as a means of state and nation consolidation. Consequently, one can argue that since its origins, there has been an important relation between state education and cultural diversity with particular implications for non-dominant groups in Western European societies.

State Education and Nation-State Consolidation

State educational systems were perceived as a fundamental tool for, in Bhabha's (1990) terms, the dissemination of the nation (Barreto, 1996, Green, 1990, Hobsbawm, 1990). They were also seen as fundamental for the construction of faithful citizens, for social mobility control, for economic development, and so for state consolidation (Barreto, 1996, Coulby and Jones, 1995, Green, 1990, 1995, Hobsbawm, 1987). Since their origin, state educational systems played a very important role in the economic, social and political 'socialisation' of Western European societies. They served both the nation and the state or, in other words, they served the politically and economically dominant nation. Western European state educational systems were created and developed to operate as a means of linking states and societies, particularly for responding to the states' needs and demands.

In his book *Education and State Formation*, Andy Green (1990) presents several examples of how state education was a significant factor in the consolidation of states' national identities, thus contributing to nation cohesion. He argues that states such as the British one, which was already quite nationally defined when the consolidation of Western European nation-states in general occurred, did not find the need to develop a state educational system as soon as others[1]. States such as the Prussian, in which issues of national identity definition and consolidation had a more problematic nature, were the first ones to perceive an ideological role in state education (Green, 1990, 1995).

This ideological role was also comprehended in terms of uses of state education for consolidation of political change. This was the case in Portugal. Like the British state, and according to De Carvalho (1996), the Portuguese one did not perceive the need for using education as a means of nation dissemination. As Monteiro and Pinto (1998) argue, the definition and consolidation of the Portuguese nation was prior to the nineteenth century. However, the Republican governments[2] of the beginning of the twentieth century recognised in education a tool for establishing their political ideology. Consequently, not only did they promote state education, but they also tried to transform it into *Republican Education* (De Carvalho, 1996). Portuguese state education was developed as a way to disseminate Portuguese nationalism in order to consolidate Republicanism (De Carvalho, 1996). The previous Portuguese Monarchic regime was presented in a submissive way in relation to external 'others'. Those particularly included England, since Portuguese nationalism at the end of the nineteenth century was very much of an anti-English nature. This was due to the tense relations between Portugal and England regarding Portuguese colonial territories in Africa (Monteiro and Pinto, 1998).

Along with an understanding of state education as a means of ideologically defining and supporting the dominant nation, Western European statesmen also perceived the value of education as a way of promoting and strengthening the economic development of the states (Green, 1990, 1995, Hobsbawm, 1975). Again, Andy Green (1990, 1995) presents important examples of this regarding the British, French and Prussian states. According to him, state technical education in England was not promoted as soon as in the other two states because the British industrial revolution occurred mainly outside academia. The French and Prussian states felt the need to depend on academia and education to promote technological development, and thus economic improvement (Green, 1990, 1995).

Immediate Implications for Cultural Diversity

> However powerful national feelings and (as nations turned into states or the other way round) allegiances, the 'nation' was not a spontaneous growth but an artefact. (...) It had actually to be constructed. Hence the crucial importance of the institutions which could *impose* national uniformity, which meant primarily the state, especially state education, state employment and (in countries adopting conscription) military service. (Hobsbawm, 1975, p.117)

To the state educational system was attributed a role of disseminator and supporter of the model of the nation-state along with the construction of nationals and citizens. This implied, among other things, an educational evolution specifically concerning and entailing means of socially, economically and politically dealing with cultural diversity. As Gundara, (2000a) puts it,

> The nation building of the nineteenth century excluded fundamental questions of diversity – interests of class, language, religion and those of territorially based national minorities – and camouflaged them within the framework of a unitary nation. (Gundara, 2000a, p.26)

One can argue, as some have (for example Coulby and Jones, 1995, Jones, 1995), that such educational processes involved ways of promoting the cultural and economic empowering of dominant groups along with means of assimilation of non-dominant ones. Among those, one finds the subordination of mass primary education to linguistic nationalism (Hobsbawm, 1987) and to an invented national history (Coulby and Jones, 1995).

Educational Systems and Cultural Diversity

Cultural diversity has been a constant presence in Western European states. The late nineteenth century British state involved the English, Scottish, Welsh and Irish groups, among others of less numerical significance (Grant, 2000). Since then, a way to deal educationally with cultural diversity has been through the educational validation and empowering of the culture of dominant groups (Coulby and Jones, 1995, Gundara, 2000a). This has implied, among other things, the use of educational models and practice, which could:

- contribute for defining and disseminating groups of 'us' and 'others';
- disseminate the dominant group's cultural identity as *the* national one;
- spread the dominant group's language and quite often religion, in the form of official ones (Coulby and Jones, 1995, Gundara, 2000a).

All through the twentieth century education has been defined according to the needs and demands of the dominant nation, and according to the established power relations between the latter and other societal groups. This seems to be still the case. For example, although being forced to acknowledge cultural diversity among contemporary Portuguese society, the Portuguese state continues to support education for the *national* Portuguese. The Portuguese *citizen* is identified with the *national*, and educational discourse regarding cultural diversity has a palliative form. Discourses on tolerance and pluralism are embodied in a universal nature. For example, in the Government's plan one reads:

> The Government's project is, at the same time, a project for stating our cultural values, our universalistic vocation, and for stating our own identity supported in the respect for the other and for diversity. But, it is also a project of union and understanding among those who use the Portuguese language as the means of communication, a cohesive endeavour in the role that must be conquered for the expression of Portuguese culture spread all over the world, and for peoples and countries which use Portuguese as their own language. (Governo, 1999)[3]

This same programme, in its section Uma Política de Plena Integração dos Imigrantes e das Minorias Étnicas - *A Policy for Full Integration of Immigrants and Ethnic Minorities* – considers education only in terms of economic support for migrant children at the university level, along with the development of educational provision for illiterate adults (Governo, 1999). Education for non-dominant groups has thus no difference from that of the majority of the Portuguese population, nor is curricular change for a culturally diverse society considered. This idea is also present in government documents on intercultural education (see for example, DEB, 1998, Governo, 1998, Ministro da Educação, 1991). These highlight the importance of intercultural education and, at the same time, involve rather assimilating elements, since cultural diversity is perceived within a universal framework.

> Portuguese culture is marked by a looked for and conscious universalism and by the multiple civilisational encounters which through the centuries, have allowed the reception of the diverse, the comprehension of the different other, the universal embrace of the particular, it is an open and mixed-race culture, enriched by the movement of a people pledging in a search for its integral dimension beyond frontiers. (...) Education should thus act on individual behaviour and decisively contribute to the integral formation of the human being, enabling him/her to live in personal freedom and autonomy, enabling him/her to enjoy solidarity dimension to the full and respect for the dignity of the other, making him/her conscious of the value of Mother Tongue, the Homeland History and of the dominant lines of national identity. (...) Even in our society, manifestations of intolerance, and in certain cases of physical and psychological violence, are inflicted on ethnic minorities (...). Aware of these actions (...) one needs to promote civic education and to contribute towards a climate of acceptance, solidarity, tolerance and respect for the right to be different which should involve the whole of education.[4] (Ministro da Educação, 1991, pp.1274-5).

Even countries such as England, whose societal pressure has long forced the educational recognition of cultural diversity, have been dealing with it ambiguously in their educational systems (Gundara, 2000a). Although pressure was made for the introduction of intercultural and anti-racist education, contemporary English education is still very much defined for the English nation. Moreover, as economy and employment increasingly establish education's orientation, so English education tends to standardise equality of opportunity and to disguise needs for cultural recognition. That is, the presentation of aims for high educational achievement standards for *all* students so that *all* may have equal employment opportunities, dislocates the discourse on the educational needs of non-dominant groups for future access to jobs. *Jobs for all* does not solve situations of intolerance and racism if the society is at the same time culturally diverse but uniformly educated to the canons of the dominant nation.

In the 1999 Report *All Our Futures - Creativity, Culture and Education*, presented both to the Secretary of State for Education and Employment and to the Secretary of State for Culture, Media and Sport, by the National Advisory Committee on Creative and Cultural Education (1999), one reads:

> We expect education to prepare young people for the world of work and for economic independence; to enable them to live constructively in responsible communities; and to enable them to live in a tolerant, culturally diverse and rapidly changing society. (National Advisory Committee on Creative and Cultural Education, 1999)

However, most government documents discuss the preparation of young people for work and economic independence but disregard life in a tolerant and culturally diverse society. For example, in the speech *Education into Employability*, in January 2001, David Blunkett (2001a) argued for the quality of educational systems within an economic framework:

> The demand on government today is for an ever-higher skills-base among individuals producing the ideas and the designs and making the goods. In our schools, colleges and universities and in training the unemployed and the

> disadvantaged, we accept our role in equipping individuals and the country with the skills and the creative, inquiring minds that will drive our economy in this new century. That is about neither purely education policy nor purely employment policy: the two are indistinguishable in this Knowledge Economy. (...) A first-class education system must cater for all and it must recognise what is valuable in the labour market. We know that the individual returns from education are high and this reflects the needs of a large part of the modern economy. (Blunkett, 2001a)

Educational policy is indistinguishable from employment policy and the two are economically defined. Within such a framework, socialisation is defined by the state's model of the worker-citizen, not the individual-citizen. Consequently, it is understandable that among the various values defined in the English National Curriculum (DfEE, 2000b) for educational transmission and promotion, cultural diversity is never explicitly mentioned.

Cultural Diversity and Models of Education

As highlighted by the examples from Portugal and England, there seems to be a persistence in some Western European states of promoting educational models which support a social and political status quo in terms of the nature, demands and needs of the nation-state. By so doing, they condition the Enlightenment ideal of the libertarian character of education to the demands of economy and politics. In fact, as some have argued (Coulby and Jones, 1995), through the pursuance of nation-state ideological maintenance, the Enlightenment educational framework that has oriented education, has been subordinated to the states' demands. This framework defined education as a means of socialisation, economic improvement and individual development.

Social Mobility Control and Social Control

Nation-states ideologists associated education for socialisation with education for nationhood, social control, and social mobility control (Coulby and Jones, 1995, Hobsbawm, 1990). States defined ways of controlling cultural diversity, particularly along with social class, through the design of specific forms of school provision and school syllabi (Coulby and Jones, 1995). Portuguese education of the 1930s constitutes a clear example of this, particularly considering the social class and gender variables. By then, the Portuguese State defined the withholding of educational provision as a means of social control (De Carvalho, 1996, Mónica, 1978). According to Mónica (1978), the control of the rural masses (the majority of the country's population in those days) was exercised through the promotion of illiteracy. The control of the industrial urban population was achieved by specific indoctrinating forms of education in which religion played a very significant part.

More recently, the role of Portuguese education as a controller of social mobility has also been expressed in terms of cultural diversity. As Cardoso (1998) argues, contemporary Portuguese education contributes to social mobility control regarding different groups through the maintenance of educational models designed for the dominant Portuguese one. Education for non-dominant groups is embodied in a palliative form. For example, intercultural education, which was finally considered by the Portuguese State in 1993, has been scarcely developed and then under a dispersal and remedial form (Cardoso, 1998, Rocha-Trindade and Mendes, 1993).

Portuguese intercultural education has been characterised by the development of particular projects in multicultural schools (Cardoso, 1998, Entreculturas, 1993, Rocha-Trindade and Mendes, 1993). Many of these were integrated in a broader project, which was launched by the Ministry of Education. This project, *The Intercultural Education Project* – Projecto de Educação Intercultural, involved several multicultural schools and was designed as a pilot scheme for future extensions of intercultural education to the whole country (Entreculturas, 1993, 1995, Ministra da Educação, 1995, Ministro da Educação, 1993). However, the project ended in the late 90s and extensions of it have not yet occurred. It is then plausible to argue that intercultural education in Portugal has been contributing very little to the social mobility of students of non-dominant groups in Portuguese society, which continues to maintain an educational system for white, middle class Portuguese.

Economic Development

Education for economic development became associated with economic educational demands of the states which, quite generally, coincided with those of the dominant nation. The development of imperial science education constitutes a good example of that. Evolving scientific thinking and the associated science education carried out in relation to the colonies occurred mainly according to the economic needs of the colonisers (Holland, 1925, Pyenson, 1990). Moreover, through the development of education for economic improvement, maintenance of the status quo has been supported. This was the case in Portugal, through an historical strengthening of science education for men, thus keeping women away from important careers in Modern Science (Santos, 2001). Similarly, that was the case in England not only regarding diversity in terms of gender but also in terms of social class (Adey, 2001, Jenkins, 1979). As social class and cultural diversity are quite often associated variables, it is possible to assume that the division of educational provision in science in terms of technical and theoretical education has possibly had important consequences for different cultural groups.

Individual Development

Finally, education for individual development was conceived within the frame of nationality, i.e. within the parameters designed for the typical national. A canon was defined, which satisfied the needs and values of dominant groups, at the same time that it contributed to their empowering (Coulby and Jones, 1995, Gundara, 2000a, 2000b). Again Portuguese state education provides good examples. Only very recently, educational concern regarding the Roma (Gypsy individuals) was manifested in Portuguese education. Nonetheless, this concern does not directly affect the educational canon defined for the white, middle class Portuguese. Individual Roma development has been totally denied by Portuguese education through omission, although officially the Roma population in the country is approximately 22,000 individuals (DEB, 1998, Governo, 1998). The total population of the country is around 10 million individuals.

Exclusion and Omission

One can consider that the subordination of state education to nation-state maintenance implied a moulding of the Enlightenment framework of education that directly contributed to the annihilation of cultural diversity, either through omission, or through assimilation and social mobility control. The libertarian character attributed to education became a privilege of the politically and economically dominant nation. Educational cultural oppression and assimilation were imposed on *the others*. State education explicitly and implicitly transmitted particular socio-economic and cultural group images, at the same time that it defined power hierarchies and feelings of belonging or exclusion (Coulby and Jones, 1995, Gundara, 2000a). The definition of education for a dominant group directly implied either a forced assimilation of those who did not belong to the group or, ultimately, their exclusion.

Demands for Recognition and State Educational Responses

Contemporary states are faced with various national voices demanding cultural recognition. The reaction of state educational systems to such demands evolved from assimilation to integration, and finally to pluralism (Coulby and Jones, 1995). Between states and groups, negotiating processes have been taking place regarding education, most frequently favouring the state, but setting important dilemmas for education providers. As Jones (1997) puts it,

> The dilemma is real for the providers of state education. Accept minority group separation in relation to education and the unity of the state may be threatened; enforce forms of differentiation that the same groups find alienating or destructive of their perceptions of identity and the unity of the state may also be threatened. There is no simple answer to this conundrum and the education system in each state usually attempts to resolve the issue in pragmatic ways

which best secure the state's own stability, rather than the educational needs of the minorities concerned. (Jones, 1997, p.5)

One can argue that it seems that contemporary negotiating processes between dominant and non-dominant groups in some Western European states established ways of dealing with cultural diversity which, on the one hand, mainly attempt to satisfy immediate educational group demands. Examples of that are the introduction of educational discourse regarding intercultural education, and the acceptance of educational provision defined in religious terms, such as Muslim or Catholic schools. On the other hand, it also seems that they do not significantly alter curricula and educational practice. Many states, however, present a concern with the education of non-dominant groups, mainly in an additive educational form, even if international organisations such as the Council of Europe have produced recommendations, guidelines and materials for education in culturally diverse societies (Taylor, 1997).

Segregation, Separation and Naturalisation

In spite of internal and external pressure to produce educational change that could provide fairer education for individuals of all groups sharing a state territory, many state educational systems seem to persist in supporting the states' ideology on cultural diversity (Coulby and Jones, 1995). That is, they have been attempting to maintain the dominant group's ideology on it. Institutional racism has been found in educational settings in countries such as England as Gillborn (1990, 1995) has highlighted. This has also been the case for cultural racism and discrimination in this country (Gillborn, 1990, 1995). State education in culturally diverse Western European countries is faced with the need to provide secure, non-racist and non-discriminating education for every individual. It also faced with the need to provide non-assimilating education for individuals of non-dominant groups, and to provide education for all in ways that will contribute to the development of fairer, less discriminating and less racist societies. However, according to David Coulby (1997), Western European state education has largely been dealing with issues of cultural diversity in ways that involve processes of *segregation*, *stratification* and *naturalisation*.

Educational legislation and provision can segregate or integrate non-dominant groups in state education systems (Coulby, 1997). By attempting to respond to particular group demands, state educational systems may be contributing to the continuous segregation of particular groups (Coulby, 1997, Gillborn and Youdell, 2000). Examples of this can be seen in permitting particular forms of education provision such as religious schools or schools where teaching is done in a particular language (Coulby, 1997). Although these schools may be seen as a fulfilment of particular groups' needs and demands, in practice they separate children in terms of specific variables and means of belonging, stressing children's sense of minority and ethnicity (Coulby, 1997).

Segregation is not a process specific to the educational relation between states and cultural diversity. States have always segregated based on different variables. As Jones (1997, pp.4-5) suggests, state educational systems differentiate in terms of *age*; *attainment*; *attendance*; *behaviour*; *citizenship*; *contact*; *curricula*; *disability/special educational needs*; *gender*; *language*; *location*; *nationality*; *'race'*; *religion*; *state*; *and wealth*. However, as cultural diversity crosses most of these variables, segregation processes have profound implications for the definition of societal positions of individuals from non-dominant groups.

Stratification is directly related to ways by which educational institutions and state education as a whole assess children (Coulby, 1997). With the development of standardised ways of assessing, designed for the dominant group (like state education itself), different children are in practice differently assessed, although without a clear acknowledgement of it (Coulby, 1997). As such, the process defines and reproduces the society's social, political and economic arrangements in a way perceived, however falsely, as legitimate (Coulby, 1997).

As educational standards become increasingly important in state education so do processes of stratification. The English case is representative of that. The Secretary of State for Education and Employment (1997) in the English Education White Paper – *Excellence in Schools*, considered the following approaches to improve education in this country:

- Education will be at the heart of government;
- Policies will benefit the many, not just the few;
- The focus will be on standards in schools, not on the structure of the school system;
- We will intervene in under-performing schools and celebrate the successful;
- There will be zero tolerance of under-performance;
- The Government will work in partnership with all those committed to raising standards. (Secretary of State for Education and Employment, 1997)

Involved in these approaches were the following means of improving schools presented in the Labour's Manifesto:

1) More money for education
2) 10,000 more teachers
3) More support for teachers in the classroom
4) A nursery place for every three-year old
5) Even higher standards in primary schools
6) Children to learn more music and sport
7) Every secondary school to develop a centre of excellence
8) Better IT and equipment for all schools
9) Stronger work-based options and apprenticeships
10) More students going to university (Labour Party, 2001)

The list above includes mainly intentions of improving the material conditions of schools. It does not involve any curricular change that may be of help for those who do not belong to the dominant group, for whom the curricula are designed. Thus, one can argue that non-dominant groups left outside curricular design will continue to be in a disadvantaged educational position, which will be reflected in examination results. Consequently, processes of stratification in England will not only continue, they may also be accentuated.

Finally, processes of naturalisation maintain the state's canon (Coulby, 1997). This canon reflects the choices of the dominant group, presented as *the* knowledge (Coulby and Jones, 1995, Coulby, 1997). Knowledge and culture from non-dominant groups are undervalued through omission. A general typical example of naturalisation processes is given by most Western European history curricula (Coulby and Jones, 1995). These tend to be 'Western' and dominant nation centred, at the same time that they tend to present depreciating images of otherness (Coulby and Jones, 1995).

Naturalisation, stratification and segregation processes are many times embodied in implicit ambiguous elements. They can appear as a response to non-dominant group educational needs, while at the same time contributing to sustaining a society's status quo (Coulby, 1997). In fact, quite often, ambiguity characterises the states' educational responses to cultural diversity. Western European nation-states tend to accept and eventually develop means to deal educationally with cultural diversity, in ways which try to solve emergent situations of crisis but which, at the same time, do not seem to contribute to profound change in the ideological and conceptual framework of the nation-state.

Since its origins state education seems to have been developed so as to respond to states' needs and to the dominant nation's demands. In many cases, it directly participated in processes of nation-state consolidation. This had profound implications regarding cultural diversity since state education was not created and developed so as to respond to groups' needs other than those of the dominant one.

State educational systems made use of Enlightenment ideals and models of education but they tended to restrict them to particular individuals. Consequently, the liberating character of knowledge has for long been an exclusive prerogative of white, upper-middle class, male individuals. State education can then be seen as an important contributor to social mobility control. Omission and exclusion of particular groups have been characteristics of state educational systems.

Recent political movements for cultural recognition have demanded educational change. However, this has been occurring in ambiguous forms. The nature of the ambiguity resides in the disparity between discourse and reality. Cultural diversity is considered at the level of political discourse but not in statutory guidelines for practice. State education systems seem to persist in processes of segregation, stratification and naturalisation. These continue to empower dominant nations. Ultimately, within this perspective, state education continues to serve mainly states' needs, disregarding important individual ones, with negative consequences for culturally diverse societies. Science education is an integral part of contemporary state education. The next section in the chapter will discuss how this particular subject has been dealing with cultural diversity.

3.3 The Case of Science Education

Like state education in general, one can argue that quite often science education developed according to dominant nation and state needs. Within such a framework, it has been involved in processes of segregation, stratification and naturalisation. Consequently, it is plausible to propose that it has favoured politically and culturally dominant groups.

Aims of a socio-economic nature have guided the characteristics of science education, including the nature of its provision, in state educational systems such as the Portuguese and the English ones. In the basis of these aims are, on the one hand, state understandings of the importance of modern science for progress/sustainable development. On the other hand, there lies a view of modern science as a means of socialisation. Both aims have important consequences (on and) for culturally diverse societies. As the discussions in this section will put forward, it is possible to argue that they are very important for the maintenance of a political and economic status quo. Both aims have an historic origin that goes back to initial developments in science education.

On the Origins of Science Education – Its Importance for Progress and Socialisation

State science education in Western Europe is a nineteenth century creation (Green, 1995, Jenkins, 1981, 2001). Its origin and development were associated with two fundamental socio-economic educational aims, which were perceived important for nation-state formation. These were:

a) science education for state economic development; and
b) science education as a means of socialisation.

Science education was aimed at the development of economic and social progress, thus reflecting the ideology of modern science[5].

At the core of those aims were the following two elements:

a) the acknowledging of the importance of technical education for the industrial and consequent economic development of states as Bailey, (1987), Betts, (1991), and Green, (1990, 1995) highlight;
b) the attribution of a socialising role to certain areas of scientific knowledge, which some scholars considered (Jenkins, 1981, Prophet and Hodson, 1988, Santos, 2001) was indirectly used as a means of social control and maintenance of the status quo.

The introduction of science subjects in Western European state education was not an easy task. Until the acknowledgement of the practical results of the Industrial Revolution, modern science tended to have an academic and restricted status, which distanced it from the general population (Jenkins, 1981, 2001, Layton, 1973, Saffin, 1973). The history of science education provision in Portugal indicates that science subjects were taught only in association with courses of Natural Philosophy and Medicine and with very low levels of attendance by the end of the nineteenth century (De Carvalho, 1996). Moreover, the history of English science education has shown that many of the first science education promoters were teachers in public schools who, according to Jenkins (2001), at the same time that they attempted to promote science education, also tried to sustain its restrictive, elitist nature.

However, scientific results presented in technological terms exposed the ideological notion of modern science as a means of promotion of economic and social progress. As Hobsbawm (1987) notes:

> Modern technology was not only undeniable and triumphant, but also highly visible. (Hobsbawm, 1987, p.27)
> In the minds of the triumphant bourgeois world the giant static mechanism of the universe inherited from the seventeenth century, but since amplified by extension into new fields, produced not only permanence and predictability but also

transformation. It produced evolution (which could be easily identified with secular 'progress', at least in human affairs). (Hobsbawm, 1987, p.244)

Associated with a belief in the value of education for nation-state economic development, such a comprehension of progress implied the attribution of a social and economic value to science education. As Green (1990, 1995) points out, it also implied the establishment of a dependent relation between it and states, which is still accepted today. This relation was the reflection of a similar one that was being created between states and modern science.

As modern science became ideologically defined in terms of the notion of progress, scientific education became a state's demand. From its origin, state science education was oriented by the aim of contributing to the economic and social progress of the state (Bailey, 1987, Betts, 1991, Green, 1990, 1995). Such an aim implied particular forms of educational provision and curriculum design. One of the most important of these was that of technical education, which in fact, can be seen as one of the original forms of state science education provision in countries such as England.

Green (1990, 1995) sees the development of technical education in the nineteenth century associated with an understanding of the former as the best means to prepare a skilled working force capable of fulfilling industrial needs, and thus securing the state's aim of economic progress. Nonetheless, industrial development was associated with human degeneration. In countries such as England, the working class was perceived as decadent. This was understood as dangerous for the morality of the society as a whole as Layton (1973), Jenkins (1981), Prophet and Hodson, (1988), and Saffin (1973) point out. In the views of Nott (1997), and Prophet and Hodson (1988), through teaching elements on hygiene, sanitation, food diet and child care in science classes, science education could be used as a means of socialisation and moral improvement of the poor. Consequently, science education was also directly fulfilling aims of social progress. These aims were, however, seen by some, as Prophet and Hodson (1988) note, as a form of social mobility control, for they directly related to a kind of science education provision that considered the poor as superficial and unable to understand abstract knowledge.

Within this perspective, although great emphasis was given to technical education for economic reasons, the definition of science education provision involved elements of social class discrimination. It became associated with notions of science education for the *use of the hands* and for the *use of the mind*, which implied a division in science education provision. The English example is well documented and exposes these aspects in a clear way.

Technical Education versus Science Education – Use of the Hands versus Use of the Mind

Late nineteenth century English development of state education provision in science was supported by a movement called *Science of the Common Things*, independently proposed by the Reverend Richard Dawes as a way to educate the poor (Layton, 1973, Nott, 1997). Studies of this movement by Layton (1973) and Nott (1997), consider that for him, science education had a practical and utilitarian importance, and it could contribute to moral and religious improvement. Within Dawes' ideas was that of the importance of learning scientific knowledge mostly in association with practical aspects of life. It was important that the application of scientific knowledge could make pupils 'alive for the humanities of life, fit them for their industrial occupations, raise them in the scale of thinking human beings and make them feel what they owe to themselves and to those around them' (Dawes, 1853, p.viii, quoted in Layton, 1973, p.40).

However, there was another movement parallel to Dawes' *Science of the Common Things*. This was proposed and supported by the Reverend John Henslow and it was based on the importance attributed to the scientific methodology. Thus, it favoured the use of the brain in opposition to that of the hands as once more

Layton (1973) and Nott (1997) point out. For Henslow (science) 'entailed a personal observation of facts and a mental effort to derive just inferences from circumstantial evidence. In this way enduring qualities would be imparted; "observant" faculties would be strengthened and reasoning powers expanded'. (Layton, 1973, p.59). Like Dawes, Henslow was also concerned with the education of the working classes. His proposed approach to science education had also embedded aims of a social nature.

As the work of Layton (1973) and Nott (1997) conclude, John Henslow's ideas were to prevail over those of Richard Dawes, and science education in England became oriented by them. Dawes' ideas were associated with a now specified kind of science education provision defined in technical terms. Consequently, technical education was associated with the study of science for *the use of the hands* and science education became associated with the study of science for the *use of the brain*. Where education in modern science developed this dual form of provision, it involved students of different social class: technical education was attributed to the working class; science education was attributed to the middle and upper classes whose children could pursue further education

Science Education and Social Mobility Control – Examples from Portugal and England

Such educational provision supported ideas on social class-based intellectual discrimination and defined a means of social mobility control as Prophet and Hodson (1988) argue. Moreover, the introduction of science education curricula, as defined by Henslow, can be seen as a way to control social mobility too. The characteristics of this original science education are summarised in the arguments for the study of science expounded by C.R. Kennedy in 1837:

a) The results of physical science are facts deeply interesting in themselves, and a knowledge of them would be found useful in the course of business or social life.

b) Though you may get a popular acquaintance with results of scientific endeavour through mathematical reasoning, the belief in them is strengthened if the nature of the steps by which they arrived at is understood.
c) We should be initiated into the mysteries of science to learn their value and to learn the extent of our own ignorance.
d) It is essential to understand the nature of mathematical reasoning if we are to reason well on moral subjects.
e) Mathematical study is a good exercise in patience and power of reflection. (Saffin, 1973, pp.178-9)

These aims, expressed under the shape of arguments, embody an understanding of modern science, which considers it *the* knowledge of the natural world. Scientific methodology is *the* means of reasoning and, finally, modern science is crucial for social and economic evolving. The survival of this framework, over that of Richard Dawes, was in accordance with the ideology of modern science. One can argue that it reflected the role of education as a linking means between individuals and the dominant group's ideologies on societies and modern science. It is possible then to accept that it implied the transmission of modern science's ideology and thus that of 'Western' supremacy.

Moreover, Prophet and Hodson (1988) argue that the preference of Henslow's framework over that of Dawes was again a result of the understanding of education as controller of social mobility. In fact, according to these scholars although both Dawes' and Henslow's models were designed to secure each individual his/her place in society, without socially moving, Dawes' ideas appeared in the eyes of the conservative groups as having more dangerous implications. These concerned their possible outcome in terms of social mobility of individuals from the lower classes. The practical characteristics of Dawes' science education design were seen as easier producers of subversive ways of thinking among these classes. Many middle class parents believed that a form of education based on practical issues would move their children away from a proximity to the upper classes, thus moving them towards lower status (Prophet and Hodson, 1988).

The development of science education in Portugal followed a similar pattern to that of England. Historians of science education such as De Carvalho (1996) note that the introduction of modern science in Portuguese state education was rather difficult. Late nineteenth century Portugal was not an industrialised country. Inputs had been given in order to develop technical education as a means to promote the country's industrialisation but with relative positive outcomes. According to Rosas (1998) and Mónica (1978), the political regimes of the late nineteenth century and of a great part of the twentieth century were supportive of an elitist society, in which illiteracy was fundamental for the control of the rural population. In 1945, António José Saraiva, when describing Alexandre Herculano's (a late nineteenth century Portuguese writer and historian) ideas on Portuguese society and education argued that

> Herculano had an ideal that he tried to apply to Portuguese life; according to this, the country was an assembly of average rural workers and land owners, and industrial owners living on the outcome of their own work (...) i.e., an assembly of owners exploiting and directly making use of the instruments of their own work. (...) Apart from this assembly, there was a group to which Herculano did not give much importance, a group of people that he instinctively despised. Those people were, on the one hand rich men, bankers, usurers, etc, whose real role in the economy of his country he never really understood; and on the other hand, there were the factory workers, declassified people, living away from the land and nature in lugubrious ways. (...) The field worker attached to the land, mistaken among trees and bulls, without any cultural means or moving facilities could not put at stake and define the interests of his own class. And, although he was the real arm upon which the population' subsistence depended, his existence was not sensed. (...) [Education then,] was not technical training for a profession that would allow the small landowner or industrial worker to earn a living; it was in fact, disinterested knowledge, independent of every profession, of every

expertise, of every working tool. It was simply general knowledge that was suitable for an assembly of owners. (Saraiva, 1945, p.82).[6]

Within such an understanding of society and education, the characteristics of Portuguese science education were necessarily associated with a theoretical framework. This was designed for *the use of the brain*, and for the privileged who could attend school. However, there were voices in the country arguing for the importance of technical education for progress. Such was the case of João Chrisostomo de Abreu e Sousa, in whose arguments one clearly finds the ideology of modern science.

> No one, whose spirit is dominated by the progressive and liberal thought of the time we are living in, will fail to recognise and proclaim that public education is one of the most essential elements, not only for humanity's moral development, but also for the constant progress of the productive forces of the nation. In man's hands, Science is, as was very recently said by a distinguished writer, an offensive and defensive weapon against nature, without which man will never be able to measure, calculate and evaluate the imperious duties that are imposed on him, in order to accomplish his mission in an honoured way, and by constant effort contribute to the disappearance of the endless needs that follow him from the first to the last day of his existence. (Ministério da Educação – Secretaria Geral, 1989)[7]

Portuguese education regarding modern science followed a dual form of provision: technical education, developed in the cities and devoted to the industrial classes; and science education, formalistic, and devoted to the elite who could attend school (De Carvalho, 1996). As was the case in England, one can see this dual provision associated with social mobility control and status quo maintenance.

In time, as education was extended to the whole population, elements of social control were associated not only with the type of provision, but also with the formalism of science education. In fact, such formalism has been maintained until today. Odete Valente (1996) characterises Portuguese contemporary science education as:

a) teaching modern science as an organised body of knowledge, which is part of one's cultural heritage and which helps to understand the natural world; and
b) teaching modern science as a group of investigative processes which structure both reasoning and action. (Valente, 1996)

In Portugal, the formalistic characteristics of science education have been criticised by people like Mariano Gago, former Minister for Science and Technology, under the argument of embodying elements of social discrimination. As he puts it

> Science education, I am very sorry to say, is still extraordinarily formalist, misconceiving the learning and teaching processes, mistaking explanations for memorised definitions, one after the other, which main aim is student selection, supporting those who come from higher educated families, and who have access to more cultural goods, over those in different circumstances. Separating from scientific quality in exchange for immediate interests or others, mainly those who have more technical aptitude, more manual skills, and less training in formalism since their childhood. (Gago, 1995).[8]

According to Mariano Gago, the nature of contemporary Portuguese science education involves elements that lead to a better science achievement among privileged groups. Its formalistic nature is perceived as a discriminating element for those who have less access to formal education at home. Compulsory contemporary science education in Portugal thus tends to discriminate by social class. Consequently, Portuguese students from higher social class backgrounds tend to be in a more advantageous position for pursuing science careers than those from lower social classes, even if compulsory science education has been democratised.

One can argue that contemporary Portuguese science education in general involves social class discriminating elements since post-compulsory education maintains the original division between technical, nowadays called professional education, and theoretical science education. Similarly, such is the case in England. From this perspective, in both Portugal and England, state educational provision in modern science seems to have developed embodied within aims of a socialising – social mobility control nature.

The Case of Gender – Science Education and Women

However, educational provision in modern science in Portugal and England may have affected individuals differently not only in terms of social class. Science education for women can also be seen embodied in socialising and discriminating aims. Science education was not understood as a female subject and for quite some time it supported social Darwinist notions of women's inferior intellectual capabilities as Jenkins (1981), Macleod and Moseley (1979), and Manthorpe, (1986) note. As the Reverend Jones put it, in the 1860s, 'boys have an aptitude for science if for nothing else' (Saffin, 1973, p.210). Abstract reasoning, experimentation, hypothesising and theorisation were not considered skills found in a girl (Saffin, 1973). Moreover, these skills were perceived as useless in the life of a *daughter*, *wife* and *mother*. In 1822, the Portuguese Bishop of Coimbra wrote in a proposal for the opening of a female Catholic school:

> In time, a girl must learn her family obligations as daughter, wife and mother. Her spirit is susceptible to great culture and her heart is even more capable of that. Thus, she must study the fundamental principles of religion and the duties of sociability, the more memorable facts of the Sacred History and of the history of her country; reading, writing and counting are indispensable tools for all those

who deal with domestic economy, who teach the children, and who sweeten the life of a virtuous consort. (Comissão de Instrução Pública, 1822)[9]

Overall, the provision of science education for women was much less developed than that for men. Where it was developed it followed a similar pattern to that of science education for boys, as research in Portugal and England has shown (Santos, 2001). Quite often, however, science education provision for women involved specific curricula thought to be in better accordance with the needs of a daughter, wife and mother. So, it involved the study of disciplines such as botany and zoology for upper class girls, and elements of diet, hygiene and child care for working class ones (Jenkins, 1981, MacLeod and Moseley, 1979, Manthorpe, 1986). Examples of courses for working class girls were those of domestic science in England (Manthorpe, 1986) and domestic chemistry in Portugal (Ministério da Instrução Pública, 1915, Santos, 2001). By 1931, modern science and women were characterised in the following way by a Portuguese writer:

> Relax then, those feminine creatures deprived of the ornaments of beauty, and also those beautiful women who already feel the horror of the ageing spectre: - science is preparing for them the most consoling surprises. (Murta, 1931, p.157)[10]

Subjects such as physics were not even considered in girls' education. Already by 1966, as Edgar Jenkins (1979) states, in England, the subjects of physics and engineering were socially 'prohibited' for girls. 'Only a girl with a divergent mentality would act [by studying Physics or Engineering] contrary to the expectations of her society' (Jenkins, 1979, p.201). In fact, in England, male associations of science teachers excluded female science teachers for a long time. Not until 1963 did the Science Masters Association and the Association of Women Science Teachers merge in order to form the Association for Science Education. (Jenkins, 2001).

Systematically, women were moved away from science subjects and consequently from science careers which in time became increasingly valued and important. In women's case science education not only operated as a barrier to social mobility (considering issues of social class as already mentioned in this section), but it also seems to have worked as a contributor for the maintenance of male oriented societies, distancing women from a key locus of power (Santos, 2001).

From Social Class and Gender to Cultural Diversity

Science education provision and characteristics appear to have been involving discriminating elements regarding the variables social class and gender. In general women tended to be distanced from science careers. Upper and middle class individuals, regardless of gender, tended to be privileged by science education provision and characteristics and thus directed to possible careers in modern science. Working class individuals seemed to be directed to technical science careers.

Social class and cultural diversity have often been associated variables in culturally diverse societies. Not too often do individuals of non-dominant cultural groups belong to middle or upper classes. For example, in 2002, in the United Kingdom the percentage of unemployed white individuals was much lower than that of any other ethnic group. The rate of unemployment for white individuals aged 16 to 24 was 11%. The same rate for black individuals was 32% and for Pakistani/Bangladeshi was 28% (Office for National Statistics, 2002). Consequently, it is not difficult to imagine that as levels and types of cultural diversity increased in Western European states, in educational terms, a great number of individuals from non-dominant groups were directed to technical education, and thus implicitly directed to industrial unskilled or semi-skilled labour.

In this case, one can consider that the characteristics of science education provision in Western European countries such as Portugal and England may have also been contributing to a distancing of individuals from non-dominant groups from science careers, and as such, from this locus of power. These characteristics tended to support dominant white male oriented societies' status quo maintenance, thus contributing to impede social mobility, and to remove women and individuals from non-dominant groups from economic and political power positions. State science education in these countries can be seen as involved in processes of segregation. It was already stated that regarding Portuguese science education the formalistic nature of the latter can be perceived as a means of discrimination in terms of social class (Gago, 1995). A similar argument can be put forward regarding cultural diversity when associated with social class in this country.

From the discussion above one can argue that overall, the development of science education both in Portugal and England attempted to fulfil the states' needs regarding the belief in modern science for economic progress. At the same time, however, it involved and reflected implicit aims and attitudes of a social nature, which had important consequences in terms of social class, gender and cultural diversity. Contemporary science education is a result of such a development, and as it will be argued it is still largely oriented by the states' needs in terms of economic progress. It will also be argued that however explicit the aims of a social nature are now in science education, it is the economic aim that mainly orients the latter. The ideology of modern science seems to be persistently embodied in science education. This has possible discriminating implications in culturally diverse societies.

Socialisation via Contemporary Science Education – Implications for Cultural Diversity

The discourse of contemporary science education explicitly involves elements of a social nature. Such is the case of concerns with the small participation of women in science careers, and with the importance of scientific literacy, for example as a means of combating exclusion. According to the former Portuguese Minister of Science and Technology, Mariano Gago,

> Alongside poverty and other general conditions, which promote exclusion and a curtailment of citizenship, one should also highlight mounting cultural factors of exclusion among which the lack of scientific and technological literacy is of massive importance. (Gago, 1996b)[11]

However, behind aims of promotion of scientific literacy and women's participation in science careers lay fears of societal maintenance of negative images of modern science. Related to such fears are others on a future lack of a good scientific community. That is, fear of low future scientific development and consequently, low economic evolution. The next paragraphs will discuss this issue in more detail.

Within the contemporary educational policy in countries such as Portugal, one finds a strong emphasis on equality of opportunity for men and women in terms of science education and future scientific and technological careers. In the Portuguese case, such an emphasis is expressed for example, in the Government's Programme (Governo, 1999), and in the document Educação, Integração e Cidadania - *Education, Integration and Citizenship*, which is the policy guideline document for compulsory education (Governo, 1998). The recognition of a scarcity of women pursuing scientific and technological careers and the input given to change this situation can be seen as a result of two elementary factors:

a) societal pressure for change regarding gender discrimination; and, more significantly,
b) the state's fear of lacking a future good scientific community, understood as indispensable for the country's economic development.

The economic possibilities brought about by information technology stressed the importance of modern science and technology for the definition of a country's position in international rankings of economic and political power. And, as Drori (2000) notes, although there is no conclusive research on the importance of science education for economic development, that importance became accepted worldwide. In fact, science education became globalised. In Drori's words, 'today the image of science education is inextricably dependent on its goals - preparing children to take their place in a prosperous, knowledge-and-technology-based, globally integrated, national economy'. (Drori, 2000, p.32).

Countries such as Portugal, which have a recent past of authoritarian political regimes that did not promote much economic growth, consider scientific and technological development a fundamental means to correct such a situation. In 1996, in a speech presenting the governmental plan for the development of information technology in the country, the Portuguese Minister for Science and Technology stated:

> It is because of the Information Society, increasingly shared and made accessible, geared towards employment and the modernisation of company's management, cultural diffusion and the fight against exclusion, scientific and technical progress and the interconnection between Portugal and the world, that we decided to prepare the launching of an extensive National Initiative for Information Society. (Gago, 1996a)[12]

On the other hand, countries such as England, which for long have relied on scientific and technological development for economic growth, insist on the importance of continuing such development. In the English Science White Paper – Excellence and Opportunity – a science and innovation policy for the 21st century, one reads:

> To be a successful nation we must make sure our science base is strong and excellent, that we have the facility to quickly transform the fruits of scientific research and invention into products and services that people need to improve their well being and quality of life. (DTI, 2000a, p.2)

In fact, in the foreword of this document, Stephen Byers, the then Secretary of State for Trade and Industry, explicitly proposes the relation between scientific and technological development and economy, which again in the words of Drori imply an image of science education 'as the precursor for human-capital-based economic prosperity' (Drori, 2000, p.31):

> It is through innovation and scientific discovery that business can provide new products for consumers. The tougher competition policy we are pursuing helps make sure that consumer desires are the drivers of innovation. (DTI, 2000a, p.ii)

As modern science evolved in an interaction with states' economic demands, so the argument on scientific and technological development for economic and social progress was increasingly stressed, as the quotations above highlight. At the same time, stress on the importance of developing science education was also increased. The original states understanding of modern science in societies, defined by the ideology of modern science that considers it as *the* knowledge and the means for social and economic progress seems thus to have been persistent. Consequently, every time that change due to scientific knowledge occurred elsewhere, a crisis in science education was declared in the 'West'. That was the case after the launching of the Soviet satellite Sputnik[13]. It was the case again after the economic boom of the countries of the Pacific Rim.

Within a framework of assurance of future good scientific communities, and within one in which societies directly depend on technological products, theoretical science education and technical science education are constantly being promoted (Drori, 2000). Moreover, women are accepted and needed as modern science workers. However, in contemporary societies such as the Portuguese one, individuals have ambiguous feelings in relation to modern science, as they perceive it as a means of progress which also embodies dangerous elements (Gonçalves, 1996). In order to improve the image of modern science in societies and at the same time to promote the existence of a future scientific community, Western European nation-states have recognised the association between modern science and societies and have focused on the development of scientific literacy (Laugksch, 2000, Lee, 2000). For example, the Portuguese Minister of Science and Technology considers that 'in modern democratic societies science education is therefore a new essential part of science policies' (Gago, 1999).

The concept of scientific literacy is not a recent one, although lately its expression in political educational discourse has become more significant along with the notion of public awareness of modern science. There are many versions of such a concept, which Laugksch (2000) fully sets out in his article 'Scientific Literacy – a conceptual overview'. Among other aspects, and according to both Laugksch (2000) and Lee (2000), these versions relate to what should be learned in modern science and about the scientific methodology, which can enable individuals to take better decisions involving issues of a scientific and a technological nature. They relate to the promotion of a good image of modern science, although also considering the importance of social, economic, cultural and ethical variables in the application of modern science products (Laugksch, 2000, Lee, 2000). The practical development of scientific literacy in science education has been very much related to a politically supported science education trend 'Science, Technology and Societies' (STS).

This trend attempts to present and discuss scientific issues in a close relation to societies. In other words, it promotes teaching and learning processes of modern science in which the latter is understood in a direct relation with technological development and societies (Ratcliffe, 2001, Solomon, 1993). As Pedretti puts it, 'STS education is premised on the belief that science education should include historical, philosophical, cultural, sociological, political and ethical perspectives. This essentially translates to teaching science in a social context'. (Pedretti, 1999, p.174).

However, *teaching science in a social context* does not necessarily imply a de-constructing of the ideology of modern science. In fact, as it has been argued, this ideology appears to lie behind the development of scientific literacy, once good images of modern science are perceived to be needed in societies. For example, the cited Portuguese Minister of Science and Technology, Mariano Gago, considers an image of modern science directly related to modern science's ideology. In the 1999 UNESCO world conference on science, he argued for scientific literacy within the ideology of modern science:

> A world forum for science education and scientific culture, bringing together projects and activities of schools and scientists all over the world could benefit from the universal appeal of science as a source of freedom and progress and from the willingness of scientists to put together different cultures and experiences. (Gago, 1999)

Contemporary science education in countries such as Portugal and England seems to maintain its original characteristics regarding its relation with the ideology of modern science. In fact, it can be seen as a promoter of such an ideology. Within this perspective, it can be seen operating as a supporter of the dominant nation, of the ideology of the nation-state and of notions of 'Western' supremacy. That being the case, it is directly participating in processes of assimilation regarding cultural diversity. As Snively and Corsiglia put it 'Western science functions as a sub-culture of western culture. In this way, non-western and minority culture students of western science may be forced to accept western values and assumptions about political, social, economic, and ethical priorities in the course of receiving instruction on western science'. (Snively and Corsiglia, 2001, p.24).

Within this process of naturalisation is embodied the support of economic, social and cultural world divisions which tend to favour the 'West' and can promote the disenfranchising of individuals from non-dominant groups along with processes of discrimination towards them. As concerns increase with scientific and technological development such as that of genetic manipulation, important questions arise on how science education addresses issues on genetics and on its relation with citizenship, discrimination and racism. Questions arise on how scientific literacy and Science, Technology and Societies, once included in curricula, deal with modern science, processes of racial discrimination and racism within educational systems that at the same time tend to value the ideology of modern science. Similarly, questions arise on how culturally diverse societies are economically and politically constructed, the role of modern science in them and in the lives of citizens of various cultural backgrounds.

As education standardisation is increasingly state supported, and governed by the comparison of exam results between different countries (Drori, 2000, Lee, 2000), one can wonder whether science education in countries such as England and Portugal have at all considered matters of cultural diversity even within issues of scientific literacy. Or if, on the other hand, science education is simply fulfilling stratification processes while trying to accomplish aims of an economic nature. Good science performances in standardised exams are considered a very good means to internationally show the future scientific potential, and thus the economic condition of a country (Drori, 2000, Lee, 2000). They do not, however, show socialisation effects on each country's individuals.

In this section, it was discussed that the development of science education in countries such as Portugal and England tended to be directly dependent on the ideology of modern science, which perceives it as the means for economic and social progress. It was argued that, consequently, within the development of science education there were aims of an economic and social nature, which may have been contributing to processes of segregation and discrimination in terms of gender, social class and cultural difference. Moreover, it was also stated, that as the relation between technological development and economy became increasingly close, states tended to increase their belief in the role of science education for the maintenance of good scientific communities. Thus, as societal images of modern science became negative, states recognised the need to improve such images and to attract students to science subjects. So, concerns with scientific literacy became explicit in educational discourse and policy, and trends such as Science, Technology and Society developed.

However, the ideology of modern science appears to be maintained in science education. Behind notions on the importance of science education for good citizenship lie aims of an economic nature, directly related to the ideology of modern science. Consequently, one can argue that images of modern science in science education are still supporting this same ideology and contributing to processes of naturalisation of individuals from non-dominant groups. Overall, like state education in general, science education appears to be participating in processes of stratification, segregation and naturalisation of individuals from non-dominant groups.

3.4 Conclusion

This chapter discussed aspects of the relation between state education, particularly science education, and cultural diversity. It argued that the development of state education in general and that of science education in particular were associated with dominant nation and state needs. Consequently, important implications for culturally non-dominant groups have been arising. Educational models tended to be developed in ways that served the needs of particular groups, while omitting or culturally assimilating others. This appears to be a persistent characteristic of educational systems even if politics of recognition have put forward educational demands of non-dominant groups.

Arguments were made on the possible involvement of science education in processes of discrimination not only in terms of cultural diversity, but also in terms of gender and social class. Its development tended to be oriented by aims of a socio-economic nature, supported by the ideology of modern science. Science education is often perceived as fundamental for economic and social progress via the permanent formation of scientific communities. At the same time, societal support for modern science is demanded. Consequently, one can argue that science education mainly developed so as to promote images of modern science which derive from the latter's ideology. Within this cadre contemporary science education can be seen as a promoter of the ideology of modern science. This ideology has negative consequences for culturally non-dominant groups, which were fully discussed in Chapter 2. Consequently, science education is possibly directly and indirectly participating in processes of dealing with cultural diversity, which are inherently favourable to the maintenance of the dominant nation and the political and cultural status quo.

Permanent recognition of processes of assimilation and discrimination of non-dominant groups has promoted the appearance of new educational voices. Intercultural education is one of those. This educational trend has been developed so as to evolve educational answers to needs of both dominant and non-dominant groups. One can then ask how intercultural education, particularly intercultural science education, has been considering the relation between nation-states, cultural diversity and modern science. A discussion on these issues is the subject of the next chapter.

Chapter 4

Intercultural Education: the case of Science Education

4.1 Introduction

Intercultural education constitutes an educational response to demands for recognition of non-dominant groups in culturally diverse societies. It has been developed at the academic level. It has been recognised by state education, and practical developments have been promoted. This chapter discusses intercultural education, focusing on scientific subjects.

The chapter's first section presents several aspects of intercultural education. It considers its general orientation and its engagement with needs from dominant and non-dominant groups in culturally diverse societies. It also introduces some examples of the implementation of intercultural education in both Portugal and England. The debate on the peculiarities of these two countries will be developed later in the thesis.

A discussion of intercultural science education constitutes the second section of the chapter. This involves elements of the academic debate on intercultural science education and it makes reference to some examples of practice from both Portugal and England. These examples will be further developed again later in the thesis.

4.2 Intercultural Education – a Model for Education in Culturally Diverse Societies

The presence of intercultural education in educational discourse and policy in countries such as England and Portugal represents a state educational response to societal pressure regarding cultural diversity. Nevertheless, the development of intercultural education has ambivalent aspects. These reflect the delicate balance between states' needs and individual and group demands.

On the Nature of Intercultural Education

In countries such as England, the history of intercultural education goes back to the 1970s and to political demands for educational recognition made by non-dominant groups. Processes of assimilation and of integration basically defined the states' first educational reactions to cultural diversity. As some (Grant, 1997, Gundara, 2000a) have argued, these disregarded the maintenance of cultural diversity and were thus disrespectful to non-dominant groups, and contributed to the general under-achievement of the latter. The roots of intercultural education can in fact, be seen in the need to improve educational achievement in non-dominant groups, and according to Gundara (2000a) 'much of the earlier research and many of the earlier publications were firmly based on deficit and disadvantaged models of subordinated groups' (p.51).

However, intercultural education has moved beyond issues of achievement in order to involve another aim, related to individual and group needs to live in and contribute to less discriminating and racist societies. Some, like Craft (1996), see it as a model of education for all regardless of having a dominant or non-dominant group origin. Also, it has moved towards involving elements of political education, which are perceived very important in and for culturally diverse societies. Once again, as Gundara (2000a) suggests,

> The role of politics in education is predicated on the fact that political education itself is necessary for all sections of society. As it is, the skills, knowledge and understanding of the political nature of society are ambiguous to large numbers of the people. Such politically uneducated or undereducated members of societies are dangerous, because they can misrepresent human and societal complexity and may opt for simplistic solutions to difficult societal issues. Political awareness, knowledge and understanding are necessary if people are to grasp the inherent complexity of society and their rights and responsibilities within it. (p.48)

Within such a framework, intercultural education involves ways of promoting better achievement by individuals from non-dominant groups, and at the same time, it involves the preparation of *all* individuals and citizens to live in a culturally diverse society. As Craft (1996) puts it:

> There may well be a need to reduce prejudice and discrimination on the part of the majority culture (or of other minorities) within the society; and also for all cultures to cultivate a detailed familiarity and understanding of the dominant culture, its core values and practices, in order to develop a common loyalty in the interests of social cohesion. (p.3)

Figueroa (1999) while reviewing multiculturalism and anti-racism in education in the UK considers that intercultural education refers to 'a complex of issues, purposes, policies, strategies, programmes and related practice across the entire educational endeavour, focused on diversity, open-mindedness, universal participation, equity, justice, antiracism, concord and related matters'. (p.283)

Intercultural education involves educational policy, curriculum, school, and community. It involves an understanding of education in terms both of individual formation and of preparation for life in a culturally diverse society, and the preparation for the labour market. Intercultural education cannot be an additive to mainstream education. As Gundara (2000a) argues, it has to be integrated into mainstream education if it is to be successful, just as education as a whole cannot be seen apart from the broad political context in which it takes place.

Theory, Discourse, Practice and Ambivalence – Examples from Portugal and England

In practice, however, intercultural education in countries such as England and Portugal is not an integral part of mainstream education. Since its beginning that theory and practice in intercultural education have been separated by important gaps. The political recognition of intercultural education has been occurring at the state discourse level, but practice has been developed in a palliative form. In Portugal for example, intercultural education has a very recent history, as migration to this country became significant already by the 1980s. Instead of producing its own model, proponents of intercultural education in Portugal have been supporting the implementation of already existing models such as those operating in England as Barbosa (1996) and Cardoso (1996) have been highlighting. According to Cardoso (1998) and Rocha-Trindade and Mendes (1993), intercultural education in Portugal is recognised at the state discourse level, but in practice it only involves specific projects developed for particular groups, supported by deficit and disadvantage models.

In a document on intercultural education in Portugal put forward by the Portuguese Department of Basic Education (DEB), it is stated that

> Intercultural and civic education should be present in each moment of school activities, in order to ensure to all students identity and responsibility learning in an increasingly open, multi-faceted and, sometimes, paradoxical society. (DEB, 1998)[1]

Intercultural education is not clearly defined, but it is related to education for citizenship and emphasis is given to identity and responsibility. However, intercultural education is mainly considered at the level of school life. In fact, in this same document one reads

> Intercultural education is a new educational perspective oriented towards:
>
> 1. better accommodating students from foreign countries or those national ones with different socio-cultural living experiences;
> 2. promoting the learning of Portuguese as second language, considering the latter as a living language open to change;
> 3. activating processes that directly confer the benefits of self-esteem, self-image and self-confidence in the 'different';
> 4. sharing knowledge, values, aesthetic expressions, techniques, cults of each culture, motivating an intellectual reflection on diversity, on common dimensions, on existing richness and prejudice;
> 5. a schooling use of educational content in a perspective of transmission of the multicultural heritage embodied in them, thus helping students to grow in interdependency, solidarity, mediation, and active tolerance. (DEB, 1998)[2]

Such a framework does not necessarily imply curricular change. It leaves a great deal of responsibility in the hands of teachers and other school actors. It is then possible to admit that within Portuguese intercultural education it may be difficult to promote discussions of issues on the nature of Portuguese society, the roots of racism and discrimination in Portugal concerning cultural diversity, social class and gender. As a result, prejudice may not necessarily be de-constructed and disadvantage may be reinforced, if difference is emphasised within a 'remedial' context.

The history of intercultural education in England is longer than in Portugal. Nonetheless, intercultural education in England has never truly characterised mainstream education even if it is mentioned at the curricular level. This is so, since intercultural education is not generally explicit in curriculum content but mainly, if at all, within teaching and learning strategies and approaches. Moreover, as increasing emphasis is put on achievement and high standards in academic terms, more curriculum content tends to remain centralised and defined by national examination papers. The creation of the Ethnic Minority Achievement Grant explicitly presents this aspect, as its aims are:

> a) to meet the particular needs of pupils for whom English is an additional language; and
>
> b) to raise standards of achievement for those minority ethnic groups who are particularly at risk of under-achieving. (DfEE, 1999)

The emphasis is on under-achievement. However, school achievement does not directly imply social, economic and political achievement, when segregation operates in the labour market and in various other aspects of wider society. Living in a culturally diverse society implies sharing societal space with different cultures and world-views. It implies an acceptance of diversity and a de-construction of prejudice. It implies an acceptance of a supra-national identity, defined by citizenship, which works as a unifier at the state level, and that does not imply a negation of other means of identification. Citizens of culturally diverse societies need a political awareness of the world in which they live and of how they can operate and eventually transform it. According to scholars such as Gundara (2000a), education cannot contribute to such a process if it takes into consideration difference only within strategies, school ethos and school life. These are important but, within a culturally diverse society, education needs to be designed for both dominant and non-dominant groups, otherwise it will not move away from original deficit models. Consequently, intercultural education should be established within the curriculum. As Gundara (2000a) puts it,

> A curriculum which de-emphasises racism and narrow ethnicisms can nurture and assist the development of healthily rooted but dynamic common cultures. Students and teachers ought to be enabled to negotiate critically core values to which all can subscribe, and which result from a broader understanding of the commonalties in a socially diverse society. (p.71)

Intercultural education has developed in countries such as Portugal and England embodied in ambivalence. Theory and practice are not coincident and, quite often, intercultural education is suggested as a remedial strategy to be applied to individuals from non-dominant groups. The increasing stress on educational standards tends to redirect intercultural education towards aims of educational achievement. Its role for individual and societal development tends to be obscured.

Intercultural education is a general educational trend. However, it has been mainly developed in subjects such as languages or history. Others, like science, have found more difficulty in developing with an intercultural orientation. A discussion on intercultural science education is the object of the next section.

4.3 Intercultural Science Education

Unlike other subjects, science education resisted the acceptance of the intercultural trend for a long time. This aspect can be seen in a direct relation with particular understandings of modern science in terms of objectivity and universalism that implied a comprehension of science education as universal to all individuals. In fact, at the heart of contemporary discussions on intercultural science education frameworks are debates on the nature of modern science and on its assumed universal characteristics.

On the Nature of Intercultural Science Education

Very few proponents of intercultural science education consider it for all students. In a 1994 article reviewing the field in the United States, Pomeroy (1994) identifies nine approaches to intercultural science education, all of them based on the education of and for non-dominant groups. As she starts her discussion, she argues that a major issue identified in state science education by educators, learners, government and industry is 'the growing disparity between racial, ethnic and gender demographics of the population as a whole and these demographics within the scientific establishment at all levels'. (Pomeroy, 1994, p.49) This issue has been perceived as essential to the development of classroom strategies, teaching-learning agendas, in order to improve the achievement of individuals from non-dominant groups.

Such strategies/agendas do not entirely discuss the nature of modern science or its ideology. According to Pomeroy (1994) they can be summarised as follows:

a) support systems for under-represented groups (p.51);
b) localised context of the science curriculum (p.53);
c) appropriate teaching strategies for different learners (p.54);
d) inclusion of the contributions of those generally omitted (p.56);
e) study of the real stories of 'Western' scientific discovery (p.57);

f) science education for language minority students (p.58);
g) study of the science in 'folk knowledge' or 'native technologies' (p.62);
h) bridging the worldview of students and that of Modern Science (p.64);
i) exploration of the beliefs, methods, criteria for validity, and systems of rationality upon which other cultures' knowledge of the natural world is built (pp.64-5).

All these agendas can be seen as part of what Southerland (2000) calls 'instructional multicultural[3] science education', defined as a way of adapting 'instruction in order to more sensitively, respectfully, and effectively teach science as it is traditionally defined'. (Southerland, 2000, p.291). More complex forms of multicultural science education can be found in what this same scholar calls 'curricular multicultural science education' (Southerland, 2000, p.291). This involves a redefinition of the epistemology of modern science 'in such a way as to adequate local or ethnic ways of understanding the physical world with that of modern science' (Southerland, 2000, p.291).

Universalists versus relativists

However, within *curricular multicultural science education*, different approaches can be considered. One of those was called by Matthews (1994) *robust multiculturalism*, which refers to acceptance of the epistemological equivalence between modern science and other forms of science. That is, robust multiculturalists consider modern science a kind of science and deny its universal nature (Matthews, 1994). Among those are scholars such as Aikenhead (1997) and Stanley and Brickhouse (2001) who support cross-cultural forms of science education. According to the latter multicultural education 'ought to be taught as a part of a culture (rather than as transcultural) and teaching students cross-cultural case studies would help them understand about other cultural views of science as well as some of the basic tenets and assumptions of WMS[4] that may otherwise be invisible'. (Stanley and Brickhouse, 2001, p.45).

Unlike robust multiculturalists, universalists such as Matthews (1994) and Hodson, (1992, 1993) believe in the universality of scientific knowledge. For them, the universal value of scientific knowledge is tested by the natural world itself. Scientists are exposed to cultural, political, economic and social constraints, but the results of their work are free from them as they refer to an objective and 'real' natural world. As Matthews (1994) puts it, 'aspects of culture do influence science, nevertheless cultural considerations do not determine the true claims of science' (p.182). For this scholar and other universalists, science education involves teaching modern scientific knowledge but it involves the presentation of images of modern science, which better account for the reality of scientific knowledge production. As Hodson (1993) puts it,

> My view is that objectivity in science is both more dynamic and diffuse than school science usually admits. It is still common, however, for the school curriculum to present scientific discovery as the inevitable outcome of the correct application of a rigorous, objective, value-free, and all-powerful scientific method. A philosophically more valid view is that scientific inquiry is an untidy, unpredictable, idiosyncratic activity that requires each scientist to choose a 'method' appropriate to the particular situation, and that scientific knowledge is *negotiated* within the community of scientists by a complex interplay of theoretical argument, experiment, and personal opinion. (p.702)

Universalists like Hodson, consider the importance of scientific knowledge in universal terms and base on it the relevance of science education as a means to contribute to economic progress, and also to individual social progress. In his framework for multicultural science education, Hodson (1992, 1993) considers that effective science education has to take account of the fact that children operate in three different worlds, which imply three different understandings of modern science. Those are: a) the child's world; b) the social world; and c) the world itself (Hodson, 1993). He also considers the importance of a tripartite understanding of science education, which involves the following elements: a) science education in a multicultural setting; b) anti-racist science education; and c) multicultural perspectives for science education (Hodson, 1992).

None of the three elements necessarily questions the nature of modern science or its ideology. Nor are they mutually exclusive. Some of them may imply an assimilationist attitude, indirectly and implicitly supporting 'Western' cultural superiority, even if the latter is not intended. For example, within point c) Hodson (1993) considers the importance of ensuring the recognition of the contribution of 'non-Western' and pre-Renaissance scientists to 'Western' cultural heritage. He also considers the importance of recognising that 'issues of justice, equality and freedom are inseparable from the proper discussion of scientific and technological practice' (Hodson, 1993, p.609).

Hodson does not fully propose a de-constructing of ideologies of modern science and how they may have been contributing to 'Western' empowering at the curricular level. In curricular terms he considers 'the design of curriculum materials that use exemplars from a variety of cultures and countries, so providing a "global view" of science and technology' (Hodson, 1993, p.690). Most other aspects are within a framework which may be very much dependent on teacher practice. Hodson (1993) considers curriculum in his framework only in terms of a possible study of the concept of 'race' in secondary science education, and in terms of a revision of all racist and offensive stereotype content.

Yet, for other scholars such as Siegel (1997), the de-construction of ideologies and images of modern science regarding its nature and its societal interaction lie at the heart of the multicultural question. According to this scholar, multicultural education is demanded for moral reasons, which are beyond the criterion of school achievement.

> So, are the epistemic presuppositions characteristic of Modern Science - that science strives, at least ideally, to achieve theoretical depth, explanatory power,

novel predictions, understanding of underlying causal mechanisms, grasp of the character of unobservable but causally important entities, and to achieve all this by way of theories whose crucial elements are testable and open to critical evaluation - themselves morally problematic? Does their assumption in science education contexts amount to a morally repugnant form of cultural imperialism, domination, or hegemony? (Siegel, 1997, p.101)

The answer to both questions among the robust multiculturalists is yes, since many of them consider that multicultural science education is about power: 'the point is, the West judged the rest of the world by its own measures of choice, Western science and Western technology, and used education to enforce change on those societies found deficient' (Cobern and Loving, 2001, p.53). In fact, 'science is used to dominate the public square as if all other discourses were of lesser value' (Cobern and Loving, 2001, p.6). For them, many universalists support modern science's exclusiveness under the shape of universalism (Cobern and Loving, 2001).

Theory and Practice – Examples from Portugal and England

The debate on intercultural science education, as presented above, is mainly an academic one. At the school and state science education level such debate is seldom heard. This seems to be the case in the United States, as Pomeroy (1994) considers. This also seems to be the case in Western Europe, in countries such as Portugal and England. In these countries, arguments on the nature of modern science appeared in education mainly within concerns with scientific literacy. Thus, they mostly appeared within a framework that tends to support modern science's ideology.

Explicit state intercultural science education in Portugal has hardly been developed. Modern science is not explicitly present in governmental discourse regarding intercultural education (see for example DEB, 1998, Ministro da Educação, 1993, Ministra da Educação, 1995). Modern science and non-dominant groups have mostly been considered in political discourse by the Minister of

Science and Technology in terms of the programme *For the Minorities* - Pelas Minorias[5]. Moreover, if and when developed, intercultural science education in Portugal tends to be involved in a remedial and instructional form. This assumption can be supported by considering the general type of intercultural science education methodologies proposed at the state level. These include:

a) the elaboration of class projects within adequate curriculum management;
b) the creation of working activities with national and international partners;
c) the promotion of professional formation areas;
d) the development of action-research projects (DEB, 1998).

Although developments in intercultural education, and consequently in intercultural science education, have been occurring in England longer than in Portugal, the instructional form of the trend seems still the predominant one. Projects within intercultural science education in England have been developed mainly with a focus on classroom diversity. This is the case, for example, of the Association for Science Teaching proposals for teaching modern science, 'race' and equality (see Thorp et al, 1994).

The instructional nature of intercultural science education in both Portugal and England can be seen as reflecting the states' understanding of intercultural science education itself as: a) a remedial strategy; and b) a response to educational demands regarding cultural diversity. On the one hand, states are responding to societal pressure regarding cultural diversity and modern science by accepting possible instructional forms of intercultural science education. On the other hand, they are supporting science education aims in terms of economic progress and 'Western' supremacy through a resistance to, or neglect of, curricular intercultural science education.

The development of intercultural science education in state educational systems has not been an easy process. Quite often it has been characterised by instructional forms of education, which attempt to remedy situations of underachievement and demands for recognition from non-dominant groups. In theoretical terms, debate has been developed on the nature of intercultural science education. At the core of this debate are important elements of the epistemology of modern science. While robust multiculturalists advocate a curricular development of various forms of science, of which modern science is only one, universalists persist on developments which take modern science as the means to find the truth about the natural world. These developments involve, however, discussions of history and philosophy of modern science, so as to socially, economically and culturally encase its development.

4.4 Conclusion

Intercultural education in general and intercultural science education in particular have been objects of academic and political debate. Theoretical frameworks have been put forward. Intercultural education in general has been politically recognised at the discourse level and by references in educational policy. Most of these references however, denote palliative forms of education so as to respond to societal demands. Quite often they are rather distanced from theoretical frameworks, and they focus on particular groups, considering intercultural education mainly as a remedial solution for these groups' educational problems.

Intercultural science education has been accepted with difficulties. The ideology of modern science seems to have been supporting the idea of the universality of science education. In other words, once modern science is considered universal, it does not make sense to introduce cultural elements in science education. This subject tends then to be understood as if it was above intercultural education.

However, discussions on the epistemology of modern science have promoted other views on the nature of modern science and science education. These have been important for the educational debate on intercultural science education. Roughly, at the heart of this debate lies universalist versus relativist understandings of the nature of scientific knowledge. Most universalists do not promote de-constructions of the ideology of modern science. Some relativists have focused on the promotion of 'other sciences', thus neglecting issues of science education for all, and its relation to the ideology of modern science.

In practical terms, in countries such as Portugal and England, not many explicit references have been made to intercultural science education either at the policy or the discourse level. The next chapters of the thesis will look in detail at issues of intercultural science education in these countries. Moreover, they will focus on the eventual presence of the ideology of modern science in Portuguese and

English science education. It is hoped that more discussions on the nature of intercultural science education may be developed from the analysis that will be offered in the next chapters.

Chapter 5

Science Education, Cultural Diversity, and Modern Science and Its Ideology in Portugal and England: the study's rationale

5.1 Introduction

In order to study the reflection in Portuguese and English science education of the relation between states, cultural diversity and modern science, particularly considering the latter's ideology, it was important to analyse such a relation beforehand. Chapter 2 discussed it by making use of specific literature, and in a non-comprehensive way. In order to contextualise such a relation in education in a general way and produce an analytical framework for studying compulsory science education in the two countries, Chapters 3 and 4 discussed state education in general, intercultural education and broad aspects of science education. Again, these discussions derived from specific literature and they were not comprehensive. This chapter develops this framework.

Section 5.2 considers the general structure of the study and the reasons behind the choice of comparative curricular analyses of compulsory science education between Portugal and England. It also presents the comparative principles, which orient the comparison.

Section 5.3 focuses on the curricular analyses. It presents the bases of the analyses, the orienting research questions, the field of study, the object of each curricular analysis as well as the used materials.

5.2 From the General to the Particular

Until now, the thesis has discussed, from a specific perspective, particular aspects of the relation between education, nation-states, cultural diversity, and modern science and its ideology. Such discussion will be further developed and detailed in the cases of Portugal and England, specifically focusing on contemporary science education curricula. These analyses will be developed in a comparative manner. Their general aim is to provide deeper and particularised insights into the reflection in Portuguese and English science education of the ideology of modern science in relation to understandings of cultural difference, and within the general framework discussed in Chapters 2 and 3. This aims to contribute towards deeper discussions of intercultural science education in these countries.

On the Study's Rationale

These discussions will follow a similar orientation to that of the general ones. Consequently, they will involve analyses of Portugal and England, cultural diversity and modern science and its ideology. Particular attention will be given to understandings of cultural difference and to the ideology of modern science in each country. The analyses will make use of historical elements, focusing specifically, however, on the present. The analyses will also take into consideration education, states and cultural diversity and will use historical examples, but again mainly focusing on the present. Attention will be given to intercultural education. The discussions of science education will be developed further than those defined in the general context. They will involve an analysis of compulsory science education curricula in both countries.

Why Curriculum Analysis at the Compulsory Education Level?

Particularly in centralised educational systems, the curriculum is a main reflector of states' understanding of the nature of knowledge and of its relation with societies. The curriculum can be seen as the result of states' choices of knowledge and of the eventual negotiated trials between states and societies concerning such choices, as Coulby and Jones (1995) note. Through it, the state tends to politically establish what it recognises as knowledge. Coulby and Jones (1995) consider that

> ...there is a connection between the epistemology current in a particular society and the content of the school and higher education curriculum within it. In the case of those countries where the curriculum of schools and/or higher education institutions is determined by the government, this connection is likely to be through the political process. (Coulby and Jones, 1995, p.23)

This is the case both in Portugal and in England. They both have centralised educational systems, oriented by a national curriculum. The science education curriculum in these countries is the result of negotiating between the states and their respective societies regarding scientific knowledge. These curricula mirror such states' understanding of scientific knowledge, of its nature, and of its role in their societies.

Within Portuguese and English science education, compulsory curricula are state aims, guidelines, methodological orientations, and choices of knowledge. The latter are common and compulsory to the majority of school individuals in these countries. In this sense the Portuguese and English science curricula are beyond most other educational elements. Their analysis can allow important understanding of the eventual participation and role of the ideology of modern science in science education in these two countries.

Why a Comparison between Portugal and England?

Comparative studies allow deeper understandings of the complexity of similar social, political and educational processes in different countries. They allow a comprehension of the particularities of each case and of the mutually influencing relations between different contexts.

Portugal and England share a set of similarities. They are both members of the EU. Consequently, they are both exposed to processes leading towards social, economic and political homogenisation. They are democratic societies, with parliamentary systems. Their societies are culturally diverse and they were both colonial empires. In terms of alliances, the political one between these two countries is the oldest in Europe (Barroso, 1998). Great emphasis is put on modern science and on education by both states (DTI, 2000a, Gago, 1998b).

However, these similarities hide many differences. The economic and political power of the two countries in the EU is not the same (Barroso, 1998). This is a reflection of the economic characteristics of each country. Portuguese democracy is less than thirty years old. English democracy is much older. Cultural diversity is a fairly recent phenomenon in Portugal (Cardoso, 1998). In England, it is older (Grant, 2000). Portuguese de-colonisation occurred in the second half of the 1970s. Science policy is a result of the 1980s in Portugal and so is mass education (Antunes, 1996, Gonçalves, 1996). Once more, these developments occurred earlier in England (Aldrich et al, 2000, Grant, 2000).

In order to discuss future developments of intercultural science education in EU countries it is important to consider the specific characteristics of each of them even if, at a superficial level, they share many common elements. England and Portugal reflect two types of countries within the EU. They represent those with 'a voice', and those searching for it. The comparison outlined in the thesis attempts to look at these two sides of the EU so that, in future political and educational developments, the 'strongest' may not define what is perceived as 'good' for all.

Structure of the Study and Comparative Principles

The study is divided into three main parts, each of them corresponding to a chapter of the thesis. Two of these parts present the analyses on Portugal and England (Chapters 6 and 7, respectively). The third part (Chapter 8) concerns a comparative discussion of the analyses on each country. The analyses are oriented by comparison principles.

The study of each country involves three sections, each of which is oriented by a comparative principle:

1. Portugal/England, Cultural Diversity, and Modern Science and Its Ideology

Comparative Principle
Aspects of the relation between state, dominant nation, cultural diversity and modern science in terms of understandings of cultural difference and of the ideology of modern science.

2. Portugal/England, Cultural Diversity and State Education

Comparative Principle
Aspects of state education regarding dominant nation and cultural diversity.

3. Portuguese/English Science Education – Curriculum Analysis

Comparative Principle
Presence and characteristics of the ideology of modern science in the science education curriculum, particularly regarding understandings of cultural difference.

Sections 1 and 2 involve bibliographic discussions and policy analyses. Besides the latter, Section 3 also involves curriculum analyses. These will be discussed in detail in the next section of this chapter.

5.3 Curriculum Analyses

The analyses of contemporary science education in Portugal and England involve issues of policy but they are mainly centred in the curriculum. The next paragraphs discuss them in detail.

Bases of the Analyses

The analyses will be developed from the general discussion of Chapter 2. Aspects regarding the eventual role of the ideology of modern science in the definition and promotion of particular understandings of cultural difference were considered in that chapter. They indicated the possible role of the ideology of modern science as:

1. a means to justify an ideological construction of *difference* as *the* construction of *difference*, and as *the* means of understanding cultural diversity.

2. to support the belief in scientific knowledge as *the* metanarrative on the natural (and social) world, and thus *the* explanatory paradigm, consequently denying value to different world visions and paradigms.

3. to support the construction of categories of diversity which are involved in social and economic discrimination.

The curricular analysis will discuss the possible presence of the ideology of modern science (as considered by each country and discussed in a previous section of the study) in the science curricula. It will also analyse the characteristics of such a presence in terms of the elements put forward in points 1, 2, and 3 above.

Intercultural education is not considered here, since it is not present in any statutory curriculum guidelines, content and materials.

Based on these ideas, several research questions were defined.

Research Questions

How does the ideology of modern science, if present, contribute to a cultural evaluation of different metanarratives on the natural world and, consequently, of different cultures, through the science curriculum?

How does the ideology of modern science, if present, contribute to a cultural evaluation of different means of reasoning and, consequently, of different cultures, through the science curriculum?

How does the ideology of modern science, if present, contribute to the definition of 'Western' means of understanding cultural difference as *the* means of understanding such a difference, via the science curriculum?

How does the ideology of modern science, if present, contribute to the development of a comprehension of cultural evolution that privileges the 'West', through the science curriculum?

Field of the Study

The study of the curriculum is focused on compulsory education. In fact, it is centred on specific common aspects of the curriculum, since it does not have quite the same structure in both countries. In Portugal, science education becomes subject based after primary education (DEB, 1995, DGEBS, 1991b, 1991c). In England, it is entirely subject based in compulsory education (DfEE and QCA, 1999a). However, both countries share a common choice of science subjects regardless of their structure in the curricula. These are mainly biology, physics and chemistry (DGEBS, 1991a, DfEE and QCA, 1999a). Other subjects such as geology are also present, but less commonly. The analysis of these three subjects constitutes the core of the study. The reasons for that relate not only to their strong presence in the curricula but also to aspects of their nature.

Physics has traditionally been perceived as the major definer of the model of modern science. Positivistic thought is often supported by traditional images of classical physics. These involve the nature of scientific knowledge and that of its production methods. The analysis of physics in the science curriculum can contribute to a better understanding of the ideology of modern science mainly regarding the transmitted images of the nature of modern science and scientific methods of knowledge production.

Biology involves the study of life. It deals with concepts of life and of differentiation – selection, classification and categorisation of life forms. Fields such as genetics introduced changes in traditional understandings of the concept of life and of 'race', along with the presentation of new ethical problems related to the potential of genetic manipulation. The analysis of biology in the science curriculum can contribute to a better understanding of the eventual presence and role of the ideology of modern science in terms of issues of human classification and categorisation directly related to discrimination and racism.

Developments in chemistry have produced important, visible, negative social consequences for example at the environmental level. Chemistry is one of the science subjects whose interaction with societies has been presented in a more visible way, particularly regarding issues of progress. Analysis of chemistry in the science curriculum can contribute to a better understanding of the contemporary ideological images of modern science portrayed in science education regarding their relation to concepts of progress and sustainable development.

Along with analyses of physics, biology and chemistry, others will be developed regarding general elements of compulsory science education such as general aims.

Object of Each Curricular Analysis

The object of each curricular analysis is defined by:

1. National science education aims and guidelines.
2. National curriculum contents of biology, physics, and chemistry.
3. National suggested teaching-learning methodologies for biology, physics, and chemistry.
4. National proposed attitudes and values towards modern science in education and their relation with individuals, groups, nations, states, and societies.

Implied in such an object choice are the following elements:

Their analysis can contribute to:

- an understanding of the nature and extent of the presence of the ideology of modern science in the orientation and definition of the science education canon;
- an understanding of the socialising aims implicitly embodied in science education regarding the development of images, values and attitudes towards modern science and its relationship with societies;
- an understanding of the depth of the presence and participation of the ideology of modern science in the curriculum as the study involves content analysis;

From the content analysis it is also possible to detect the implicit presence of notions of science education as a beyond culture - supra-cultural activity.

Each curricular analysis will discuss:

1. The curriculum orienting conceptual framework; and
2. The curriculum content characteristics

For each of these points, and deriving from the elements to be studied, involved in the research questions, the following data organising headings are used:

1. Modern science as the metanarrative on the natural world
2. Scientific means of reasoning as the means of reasoning
3. 'West' and progress/sustainable development

The focus of this thesis is state science education. Curriculum orientation, content choice and characteristics are definers of the state's conceptual framework of science education. The analysis may contribute to an understanding of the state's conceptual comprehension of the role and characteristics of the ideology of modern science in science education regarding constructions of cultural difference. As content characteristics are also included, the results of the analysis may also contribute to a better understanding of the transmission of the ideology of modern science through science education, necessarily concerning constructions of cultural difference.

Used Materials

As the analyses focus on state education, the following materials will be used in their development:

Educational law.

State documents on science education such as government reports.

National Curriculum materials involving aims, objectives, content and suggested teaching and learning methodologies.

Along with these, other materials are considered in the general study of each country. These involve Ministers' speeches, White Papers and Green Papers, law documents, reports and secondary sources of an academic nature.

5.4 Conclusion

This chapter presented a rationale for a detailed analysis of science education, understandings of cultural difference and the ideology of modern science in Portugal and England. It established a link between general and particular analyses while justifying several of the choices made. Following the elements outlined in this chapter, the next chapters will develop and present such analyses.

Chapter 6

Science Education, Cultural Diversity and Modern Science and Its Ideology in Portugal

6.1 Introduction

This chapter derives from the discussions put forward in Chapters 2, 3, and 4. It contextualises them. Particularly, it discusses issues of understandings of cultural difference and the ideology of modern science (as considered in Chapter 2) in Portuguese compulsory science education.

Following the orientation put forward in Chapter 5, the chapter starts by discussing political and social Portugal, cultural diversity and modern science and its ideology in the country. This first analytical section constitutes a discussion of the idea of Portugal as the closest example to the model of the nation-state along with the construction of Portuguese nationalism and otherness. Particular attention will be paid to recent political and economic change in the country, which produced not only an increase in cultural diversity, but also the visibility of various forms of racism. European Union integration will also be discussed along with some of the compulsory changes that it introduced. Special attention will be paid to Portuguese ideological understandings of modern science.

Portuguese education also suffered major transformations during the last decades of the twentieth century. These mainly resulted from broader change as discussed in the previous section. The second analytical section of the chapter is then a discussion on Portuguese education considering intercultural education, too.

The analysis of aspects of compulsory science education in Portugal constitutes the third section of the chapter. This analysis involves: a contribution to the understanding of the relation between modern science policy and the development of science education taking into account the ideology of modern science; a discussion of the nature and characteristics of the presence of modern science and of its ideology in compulsory education; and a curricular analysis of biology, physics and chemistry in the science curriculum. This analysis is oriented by several research questions, which attempt to understand the nature and characteristics of the ideology of modern science in such a curriculum. Finally, the section is concluded with the results of the analyses summarised in answering elements of the various orienting research questions.

6.2 Culturally Diverse Portugal and Modern Science and Its Ideology

Cultural diversity is a notable feature of Portuguese society. Movements of population mainly from other EU countries, Brazil, former African colonies, along with recent influxes of economic migrants, mainly from Eastern Europe, following an expansion of the country's building industry have increased the level of cultural diversity in Portugal (Cardoso, 1996). This increase is a sign of social, political and economic change. So is the development of modern science.

Portugal: the example of 'the' nation-state

During the past two centuries, Portugal was not perceived as a culturally diverse country. Indeed, according to some such as Monteiro and Pinto (1998), it was considered as the closest approximation to the model of the nation-state. From the middle of the eighteenth century onwards, cultural diversity was disregarded in Portugal on account of the official end of the Moorish and Jewish presence in the country. Nevertheless, individuals from former Portuguese colonies have always lived in Portugal. The Roma (Gypsy) presence in the country was also constant. However, neither of these groups was politically recognised by the state or by the society (Monteiro and Pinto, 1998).

Monteiro and Pinto (1998) argue that one of the bases of Portuguese national ideology has been the idea of the cultural homogeneity of Portuguese society. According to them, the definition of the Portuguese territory in terms of land 're-conquest' from the Moors, the lack of significant linguistic and religious minorities, the lack of cultural regionalisms promoted the development of such an idea. Communities like the Roma (Gypsy) were not politically recognised and linguistic diversity, defined in terms of the use of dialects, particularly by populations living near the border with Spain, was not significant. The ideology of *Estado Novo* (fascist political regime from 1933 to 1974) officially denied any kind of cultural diversity. Until at least 1974, Portugal was perceived as one homogeneous nation, with Portuguese as the common language, Catholicism as the common religion, and with an identity defined by a glorious Middle Ages past and an African Empire (Monteiro and Pinto, 1998). This image of homogeneity is still prevalent in many Portuguese minds today.

Nationalism: on the Portuguese others

The development of Portuguese nationalism is a characteristic of the nineteenth century, as was the case in most Western European countries. Following once more Monteiro and Pinto (1998), one can argue that the idea of Portugueseness appeared with the Liberal movement of the first half of the nineteenth century, initially as an opposition to Iberianism. The latter constituted an ideology on the unification of the Iberian Peninsula. Portugueseness was further developed by the Republican movement of the late nineteenth century as a means to take over power from the monarchy (Monteiro and Pinto, 1998). Republicanism was introduced in Portugal by 1910. From those days, dates the creation of a national flag, a national anthem, and a profile of Portugueseness, which would later be perfected and strongly disseminated by the fascist regime of Salazar (1933-1974) (Monteiro and Pinto, 1998).

The development of Portuguese national identity as an 'us' category implied the creation or recognition of groups of 'others'. As already suggested, the beginning of Portuguese nationalism can be seen in association with a response to a possible unification of the Iberian Peninsula. Portugueseness was then mostly defined in opposition to Spanish otherness. From those days (1868) dates the celebration of the 1st of December as the day of independence from Spanish domination[1] (Monteiro and Pinto, 1998). The 1st of December continues to be a national holiday in Portugal, and the Spanish are the Portuguese *traditional enemies.* With contemporary Portuguese and Spanish membership of the European Union, 'the Spanish' as the others lost their importance in political terms, although their economic importance has increased. Consequently, and as Barroso (1998) puts it, Portuguese people no longer 'fear' a Spanish territorial invasion. They now 'fear' an economic one.

The Spanish were not the only group defined as the others in the nineteenth century. During the century's first half Portugal faced a period of political instability characterised by the French and English presence in the country (Monteiro and Pinto, 1998). The French and the English became another two important groups of others. Portuguese nationalism was also defined as anti-French and anti-English (Monteiro and Pinto, 1998). The English as the others acquired increasing importance with the 1890's Ultimatum on the definition of the Portuguese African territories. England had always exerted control over the Portuguese African colonies through a set of alliances, but when Portugal tried to territorially unify Angola and Mozambique, England threatened the country with a possible invasion. The Republican movement exploited the idea of the English as the others in the spread of Portuguese nationalism (Monteiro and Pinto, 1998).

Nevertheless, and unlike most Western European countries, the Portuguese state and nation were already well-defined in the nineteenth century. As Monteiro and Pinto (1998) point out, the Spanish, the English and the French others did not constitute a support for nation-state cohesion. They constituted an indirect justification for the country's decadence. The political dependency on England and the independence of Brazil were perceived as the ultimate form of decadence of a country that had once been great. Thus, Portugueseness became defined in terms of this glorious past, mainly characterised by the overseas expansion, and by the holding of an African Empire, along with the need for regeneration. Portuguese nationalism and colonialism were directly related, together with a particular construction of black otherness (Monteiro and Pinto, 1998).

Salazar's regime was characterised by an attempt to keep the African colonies as long as possible (Correia, 1998). Rapid de-colonisation took place after the 1974 democratic revolution and after thirteen years of independence wars. According to

Correia (1998), Salazar's ideology focused on the particular relation between nationalism and imperialism. The construction of black otherness was defined by opposition. It was supported by the notion of the non-racist nature of the Portuguese as well as that of Portuguese colonialism.

The dissemination [in Bhabha (1990) terms] of the Portuguese nation involved the idea of the Portuguese as pacific religious individuals, easily adjustable to various environments and open to miscegenation (Cardoso, 1998). The attributed charitable and Christian nature of the Portuguese, along with the belief in their openness to other cultures, promoted an internal construction of Portugueseness in non-racist terms (Cardoso, 1998). In other words, the Portuguese became used to perceiving themselves as less racist (if at all) than other colonisers. Several aspects were considered basic in this process. One of these was the association of religion with colonialism – the Portuguese had the moral and religious duty to 'Christianise the savage black' (Cardoso, 1998). Another aspect was the development of a movement called *Lusotropicalismo* (Cardoso, 1998).

Lusotropicalismo was developed by the Brazilian sociologist Gilberto Freyre and as Cardoso (1998) puts it, it portrayed 'Portuguese colonialism as an essentially humanist process, in which racial superiority and ethnocentric tendencies were absent, which was based upon respect for cultural differences and was favourably disposed towards pluralism resulting from the biological and cultural mixing of the Portuguese with local populations' (Cardoso, 1998, p.197).

The association between nationalism and colonialism was a very important support and justification of Portuguese colonisation and of the importance of its maintenance. As a result, ideas from *Lusotropicalismo* tend to prevail in contemporary Portuguese imagination with complex consequences for the African communities who now live in Portugal, as Falcão (1998) and N'Ganga (1998) have been highlighting. With de-colonisation and war, Africans from Portuguese former colonies started to move to Portugal. In 1999, they represented approximately 0.89% of the Portuguese population (INE, 1999), constituting the largest group of migrants officially residing in Portugal, approximately 47% of the total legal foreign population (INE, 1999).

Migration and Racism

African migration to Portugal has been quite characterised by individuals from Cape Verde (approximately 49% of the whole African group (INE, 1999)), Angola (approximately 20% of the whole African group (INE, 1999)) and Guinea-Bissau (approximately 16% of the whole African group (INE, 1999)). Individuals from Mozambique, São Tomé e Princípe and other parts of Africa constitute the fourth largest group of African migrants (approximately 15% of the whole African group (INE, 1999)). African migration is characterised by diversity, although the latter is not acknowledged by the dominant Portuguese nation. The 'black other' is still mainly defined in racial terms (Falcão, 1998).

Falcão (1998) considers that racial forms of discrimination, intolerance and xenophobia define skin colour based racism in Portugal. In the view of Rodrigues de Areia (1998), although cultural racism is also present, skin colour based racism is more significant in Portuguese society. Oral and physical violence has occurred. So has been the case for institutional racism regarding issues such as housing and security. For some, like Falcão (1998), the ideology of the non-racist Portuguese character has been a means of preventing data collection and analysis about such issues.

At the state level, however, attempts were made to change this situation. Following the signature of the International Convention for the Elimination of All Forms of Racial Discrimination, the Portuguese Government passed a law (Law 134 of 28th August 1999), which directly deals with issues of racism, forbidding and defining means of dealing with discrimination based on race, skin colour, nationality or ethnic origin (Presidência do Conselho de Ministros, 1999). This is an issue that the Portuguese Constitution also considers. The latter includes as well the case of religious discrimination (Governo, 1997b). According to Law 134, mentioned above, racial discrimination is 'any kind of distinction, exclusion, restriction or preference based on race, skin colour, kinship, national or ethnic origin, which aims at or produces as a result the annulling or restriction of recognition, fruition or exercise, in conditions of equality, of rights, freedoms and warranties or of economic, social and cultural rights' (Presidência do Conselho de Ministros, 1999)[2]. The law also considers the creation of the *Comissão para a Igualdade e Contra a Discriminação Racial* (Commission for Equality and Against Racial Discrimination), which has among its aims the collection of data on racial discrimination in the country (Presidência do Conselho de Ministros, 1999).

The African group of migrants is not the only group of foreigners living in Portugal. 1999 statistics indicate the number of 190,896 individuals of foreign origin officially and legally living in the country (INE, 1999). This number constitutes approximately 1.9% of the country's total population (9,988,520) and it has approximately doubled since 1986 (INE, 1999) with the expansion of the Portuguese economy. During the year of 1999, a total of 14,476 individuals requested resident status, of which 5,010 are of European origin (INE, 1999). In fact, the group of legal migrants of European origin (mainly originating from the EU) is the second largest in the country (56,731 individuals (INE, 1999)). However, European otherness has always been differently defined from black otherness.

Europe: both 'us' and 'others'

Portuguese images of Europe and of the Europeans have changed during the twentieth century. Scholars like Dacosta (1998) argued that Salazar's political ideology disseminated an image of Europe defined in terms of opposing otherness. Portugal was a politically isolated unique Atlantic nation, having an African colonial empire. The dissemination of this Portuguese nation was seen as a means to support Salazar's refusal to decolonise. Within such an ideological framework, Europe was presented as a political enemy. In reality, however, and as Brandão de Brito (1998) and Telo (1998) have been arguing, Salazar's regime was never entirely distanced from Europe. Salazar defined a balance between his regime's political needs and the demands of other states. For example, Portugal was a founding member of EFTA. According to these scholars, this ambiguity between political discourse and practice in relation to Europe can be seen as a favourable element for the contemporary Portuguese identification with the European Union. Within such a framework, one can argue that European otherness is more diluted than African/black otherness in Portuguese society.

Barroso (1998) and Monteiro and Pinto (1998) consider that European Union membership was perceived by most Portuguese politicians of the democratic era as a means for economically and socially improving the country, along with a definitive stabilising of its democratic political structure. Democratisation is by no means contested in Portugal. The Portuguese economy expanded, particularly in the late 1980s and early 1990s. Economic improvement promoted the establishing of an economically expanding and well-off middle class (Cabral, 1998, Ferreira de Almeida, 1998). This class is not homogeneous, and its members, who engage in scientific and intellectual work, mainly define the contemporary values of Portuguese society as Ferreira de Almeida (1998) notes. According to him and others such as Barroso (1998) and Cabral (1998), these values tend to follow models based on those of the northern part of the European continent, largely because the Portuguese population was eager for an improvement of social and economic conditions.

Portugal's membership of the European Union has also been perceived as a means of improving the self-esteem of the Portuguese. Barroso (1998), for example, has considered that the low self-esteem of the 'nation' has been a basic element within issues of Portuguese national identity. European Union membership can then be seen as a means of regeneration, expressed for example by Portuguese attempts to define a politically central role in the Union. Belonging to the EU seems to have constituted a very important means to prevent a Portuguese identity crisis, which might have occurred with de-colonisation.

With the Portuguese 'integration into Europe', those Europeans with an EU origin and living in Portugal tend to be not so strongly defined as others like African migrants. Along with EU discourse, Portuguese contemporary political discourse has also changed in relation to diversity. Words such as pluralism and ethnicity are now familiar to the Portuguese nation. This discourse tends nevertheless to be largely defined on an external basis, for example on references to the culturally diverse nature of the EU. Implicitly supported by elements from *Lusotropicalismo*, Portuguese political discourse on diversity is mostly defined in terms of universalism. Thus, it values tolerance and multiculturalism within a broad and geographically undefined framework. Tolerance and respect for cultural difference are presented as universal values. Little is said with regard to the promotion of those values specifically within the Portuguese society (Falcão, 1998).

Universalism, Minorities and Social Exclusion

Portugal is often defined as a country open to interaction with other cultures and cultural sharing. Yet, that does seem to be the case of contemporary Portuguese society. Such a definition however, has important consequences for those living in Portugal, who do not belong to the dominant group. Because Portuguese society does not yet accept itself as culturally diverse, groups of individuals of non-Portuguese origin tend to be defined as economic migrants, temporarily residing in the country. Within this framework, cultural diversity is perceived as a temporary phenomenon. For example, in policy for minorities, the Government plan considers the importance of 'facilitating the reception and transference of retirement pensions to the immigrants' countries of origin' (Governo, 1999)[3].

Non dominant groups contemporarily living in Portuguese society are faced with several difficulties. Groups of migrants can be confronted with various forms of racism, particularly if their members are not white (Falcão, 1998). Most of these groups face severe economic and social difficulties (Falcão, 1998). Thus, not only are they confronted with possible racial discrimination, but they also tend to face social and economic exclusion.

Issues of exclusion are a contemporary political concern mainly expressed in political discourse. Social and economic inclusion policies have been proposed (see for example, Governo, 1999). Migrants have been affected by such policies too. Nevertheless, many of these policies do not attend to the particular needs of such migrants, since they are mainly social class and economically based. The Government Plan includes a section on migrants and ethnic minorities – *Uma Política de Plena Integração dos Imigrantes e das Minorias Étnicas* – A Policy of Full Integration of Immigrants and Ethnic Minorities. In this, issues such as housing, health and education are considered, although one finds a certain discourse ambivalence. Cultural diversity is above all understood in terms of migration and thus as a temporary phenomenon. Consequently, several of the policies proposed in the Plan's section do not fulfil the needs of groups, which, in reality, have already settled down in the country even if the term 'integration' is used in government policy (see Governo, 1999).

In practice, there are very few Portuguese governmental bodies that directly deal with issues of cultural diversity in the country. Among those one finds the Secretariat for the Co-ordination of Intercultural Education Projects, which deals with education and minorities in Portugal, and the High Commission for Migration and Ethnic Minorities (Alto Comissariado para a Imigração e Minorias Étnicas - ACIME). Both governmental bodies also focus a great deal of their attention on issues related to the social exclusion of migrants and ethnic groups.

Social Exclusion and Modern Science

Social exclusion has been referred to in Portuguese policy in various forms, one of which relates to the lack of information, particularly information technology as a means of social exclusion. This idea has been stressed by the former Portuguese Minister of Science and Technology, Mariano Gago, and according to him, 'alongside poverty and material conditions inciting social exclusion and the reduction of citizenship, one should as well stress, in its increasing form, cultural factors of exclusion among which deprivation from scientific and technological literacy is today of unequalled gravity' (Gago, 1996b)[4]. This is a rather important perspective once it moves the discourse on exclusion from economics to culture.

The Minister considered the concern with the lack of scientific and technological literacy as a means of social exclusion, also in the specific case of cultural diversity. Included in the project *Cidades Digitais* (Digital Cities), the Ministry of Science and Technology launched the programme *Pelas Minorias* (For the Minorities).

This project dates from 1998 and it is centred in Lisbon's metropolitan area, where most migrants tend to settle (MCT, 1998), although it is the government's intention to expand it (Governo, 1999). The project involved the creation of a website which includes a great deal of information on the migrants' various countries of origin, on policies in relation to migrants in Portugal, on events, as well as forums of debate. Computers were installed in migrants' associations. These were supported by the presence of information technology experts in order to teach the groups how to use information technology, and how to develop computer skills (MCT, 1998). The project rests upon the following basic assumptions: (i) 'a fight against info-exclusion'; and (ii) 'a contribution to the reinforcement of the cultural identity and living perspectives of the involved populations, as well as to their integration in an open and pluralistic information society' (MCT, 1998)[5].

Portuguese Understandings of Modern Science

This project is embedded in the acknowledgement of the role of modern science in culturally diverse societies. Basically, what underlies the project is the recognition of the role of information technology in contemporary societies. This role is clearly considered in the Government's Plan when defining the establishment of an information and knowledge society as a central government priority (Governo, 1999). Such an aim is embodied in and implies particular cultural and economic aspects associated with modern science and understandings of it. It implies an understanding of societies in a direct relation to scientific and technological development, affecting both micro and macro levels. Information technology is considered in regard to issues of citizenship, as it is perceived as a means of economic improvement (Gago, 1996a, Governo, 1999, MCT, 1998). 'It is because of an increasingly shared and accessible Information Society, mobilised for employment and modernising of company administration, for cultural diffusing and battling against exclusion, for scientific and technical progress and for the interconnection between Portugal and the world, that we defined the preparation of the launching of a great National Initiative for an Information Society' (Gago, 1996a)[6].

Contemporary Portuguese science policy is mostly oriented by two main objectives. The first of these objectives concerns issues of sustainable development (Governo, 1988, 1996, 1997a, 1997b). As Gonçalves (1996) notes, the country's economic and social underdevelopment of the second half of the twentieth century is largely associated with the Portuguese lack of scientific and technological evolution. A defined Portuguese science policy is a result of the late 1980s (Gonçalves, 1996). The creation of the Ministry of Science and Technology occurred in 1996. In the 1988 Law on Scientific Research and Technological Development one reads that 'the national R&D policy is one of the country's warranties towards modernisation as well as economic, social and cultural development, being an integral part of the national strategy to utilise and appreciate national resources of all kinds, to promote innovation and expand knowledge' (Governo, 1988, p.3363)[7].

The second main objective of Portuguese contemporary science policy regards scientific and technological literacy (Gago, 1995, 1996a, 1997, 1998a, 1998b, 1998c, 1999, 2000). The development of scientific and technological literacy is perceived as a means of promoting full citizenship. In a speech given by the Minister of Science and Technology in a 1996 conference on modern science, one reads that 'we understand that the diffusion to, and appropriation of, scientific literacy by the largest possible number of individuals, and the social evolving, civilising processes which Science directly or indirectly makes possible, are fundamental minimal conditions for modern citizenship' (Gago, 1996b)[8].

Both objectives can have profound implications regarding issues of cultural diversity in Portuguese society. The development of scientific and technological literacy is taken as a means of citizenship empowerment. The project *For the Minorities* is an example of that. Embodied in both objectives, as well as in all science policies, are elements of a particular understanding of modern science. The first of the considered objectives has already highlighted part of this: modern science as a means of sustainable development. Regarding the second one, according to Mariano Gago, 'successive generations of scientists, teachers, students and other educated and generous individuals have fought, under difficult conditions, for the development of scientific and technological literacy in Portuguese society, having suffered persecution, and frequently facing public incomprehension and neglect. They did it under the conviction that they were serving a cause of freedom, contribution and progress' (Gago, 1998b)[9]. Modern science is seen associated with freedom and progress within its modern model. However, once again as the former Minister puts it, 'Portugal wishes to be an active partner in this challenging process of bringing the benefits of science and the critical and free intelligence of scientific culture to the peoples of the world' (Gago, 1999). In other words, Mariano Gago envisages a Portuguese scientifically literate society in which the relation between modern science and it will also be under scrutiny.

For most of the twentieth century Portugal has been perceived as the closest example to the model of the nation-state. Understandings of cultural difference in the country were mainly defined in external terms: the Spanish, the English and, mostly, the African others. The ideology on the universalistic and non-racist nature of the Portuguese dominated political and nationalistic discourse. This has been seen as having important consequences for contemporary understandings of cultural difference in Portugal. Change attracted migration to the country. However, cultural difference tends to still be perceived in an external form, as migration is understood in a temporary way, and assimilating and integrating policy usually prevails over pluralistic discourse.

The Ministry of Science and Technology was one of the governmental bodies that gave particular attention to issues of cultural diversity, while developing initiatives to diminish social exclusion. This policy reflects an understanding of modern science in a direct relation with societies. This is a fairly recent understanding in Portugal, where modern science policy is a characteristic of the 1990s. The majority of the political elite did not consider scientific and technological development important in a rural country. This was the prevailing ideology for most of the twentieth century in Portugal. Political and economic change demanded the development of modern science. Contemporary understandings on the latter tend to perceive it as a means of sustainable development and to promote citizenship and reduce social exclusion via scientific literacy. Underlying such understandings one also finds elements of the ideology of modern science and the need to fortify confidence in scientific and technological evolution.

Change in Portugal has raised new issues in regard to traditional understandings of cultural difference and modern science. Many of these figure in state policy and practice. Educational change was also a demand of the late twentieth century. One can then question how such issues in respect of cultural difference and modern science were reflected in contemporary Portuguese state education.

6.3 Portuguese State Education and Cultural Diversity

A great deal of contemporary Portuguese political discourse is dedicated to education and educational change. Both Government and opposition parties consider education a basis for future sustainable development (Governo, 1999, PSD, 1998). Education in Portugal underwent important transformation since the introduction of democracy in 1974. A great deal of such a change has been oriented by two essential factors: a) internal political transformation, as Correia, (1999) points out; and b) pressure on the country's modernisation stressed with EU membership as, for example, Stoer and Cortesão (1995) have been noting. Major consequences of this change were the universalising of compulsory education and the comprehensiveness of education in general (Cardoso, 1998, Stoer and Cortesão, 1995). Both aspects mentioned above had effectively occurred already by the 1980s, and they caused important changes in the country's educational system.

From General Illiteracy to Mass Education

The 1980s educational reform introduced change in educational provision and in the ways by which education was understood in the country.

> The educational system is the group of means through which the right to education is accomplished, which is expressed by the warranty of a permanent formative action for favouring global development of the personality, social progress and society democratisation.[10] (Governo, 1986, p.3067)

Article 1 of *Lei de Bases do Sistema Educativo* (1986 Education Act – still effective today) above quoted is complemented by several educational principles, of which the following one is of particular importance: 'All Portuguese have the right to education and culture as defined by the Constitution'[11] (Governo, 1986, p.3068).

This principle is representative of a comprehensive understanding of education, which was politically disregarded until the second half of the twentieth century. During the dictatorship period education was mainly a privilege of the élite (De Carvalho, 1996). Traces of Salazar's educational ideology on the value of illiteracy as a means of social control (Mónica, 1978) are seen to have dominated educational policy until the late 1960s (De Carvalho, 1996). As Brandão de Brito (1998) argues, educational reform was designed mainly according to specific élite demands. Such was the case of the 1960s input given to technical education, which was directly related to demands of industry for a skilled working force.

The reformers and revolutionary promoters of the late 1970s understood education as a literacy tool and as a means to consolidate the newly installed democracy (Correia, 1999). However, fast economic and social change, associated with adaptation to the European Union political and economic framework facilitated the development of different educational discourses. Several of these were influenced by perceived educational crisis in EU countries and they did not directly relate to the Portuguese context as Stoer (1994) notes. The contemporary Portuguese educational system is the result of reform supported by a conjunction of ideas from these discourses.

Educational Diversification, Educational Democratising and the Democratic School

Antunes (1996) considers that three main ideological discourses have oriented the evolution of Portuguese education since 1974. One of these relates to the importance of education as a means to compensate for delay in Portuguese social and economic development. This discourse can be called *educational diversification* (Antunes, 1996). Another educational discourse is that of *educational democratising*, which involves an educational policy which is at the same time directed to economic change and societal transforming. Education is perceived as a means to deal simultaneously with economic modernising and social and political democratisation (Antunes, 1996). The last of the three educational discourses is that of *the democratic school.* Educational policy within this discourse is defined as societal transforming and utopian-culturalistic, that is, education is perceived as a means to deal with social and economic objectives which fulfilment depends on the democratic consolidation of the society. Education for democracy is at the core of this discourse. Democratic consolidation is understood as the basis for economic development (Antunes, 1996).

These three discourses resulted mainly from the country's acknowledgement of the possible role of education for social, economic and political change. The *democratic school* was a characteristic of the late 1970s in a direct relationship with the introduction of democracy in 1974 (Stoer, 1994). However, these discourses can also be seen as an outcome of the evolution of internal and external politics. For example, educational reform of the 1980s and a great deal of the 1990s was defined within a neo-liberal and post-fordist framework characteristic of northern and central European countries of the EU (Correia et al, 1993, Correia, 1995, 1999, Stoer, 1994).

Implications from External Influence

Portuguese education was perceived within a frame of modernisation and educational crisis (Stoer, 1994). It became oriented towards the labour market, leaving little room for issues of citizenship. At the same time, increasing emphasis was given to private education particularly at the higher education level (Stoer, 1994). According to Stoer (1994) the educational results of the 1980s and 1990s were contradictory by nature and did not respond to the needs of a semi-peripheric country such as Portugal. Educational development occurred with two different forms: on the one hand, mass education was promoted, and on the other hand educational submission to the market was also manifested.

> In fact, Portuguese concerns in the 1980s are considerably different both from the fordist ones (...) and from the 'revolutionary' ones (...). As a result, the

meritocratic school in Portugal, which in the 1970s starts setting apart its 'mitigated' status (seriously threatening to be transformed into the democratic school), engages in a new developing phase in the 1980s. This phase, under the leadership of the 'modernising state', considers in Portugal the fordist crisis of central European countries (with regard to education) at the same time that it invests in the continuing consolidation of the official school (of masses) for all.[12] (Stoer, 1994, p.17)

On the Contemporary Educational System

Today's Portuguese educational system is the result of continuous change. Compulsory education integrates nine years and discussions are being held to make secondary education compulsory, too. It is comprehensive and universal. The nine years of compulsory education are divided into three key stages: the first of those – Key Stage 1 – concerns primary education. It involves a minimal curricular timetable of twenty-five hours per week and the curriculum is area/theme based. Key Stage 2 includes two years and it already involves study areas and separate subjects. Finally, Key Stage 3 is subject-based and it covers three years. Education is compulsory in Portugal until the age of 15.

Key Stage 1: Students aged 5-9; 4 years.
Key Stage 2: Students aged 9-11; 2 years.
Key Stage 3: Students aged 11-15; 3 years

Orienting compulsory education are state-defined general objectives, which each school will organise and deal with according to the suggested elements:

- transversal and specific learning experiences defined in main objectives of each key stage;
- a reference established by the official national curriculum;
- local and/or regional components of the curricula (if the school has made some options with regards to that)[13]. (DGEBS, 1991a, p.2)

Secondary education involves three years. In curricular terms, it is subject-based and it involves a compulsory component and a chosen one. The following subjects define the compulsory component: Portuguese, Introduction to Philosophy, a Foreign Language, and Physical Education.

The embodied understanding of education and that of the role of the state in it are defined as:

> The role of the state is to define guidelines and objectives, to regulate action, to support initiative, and to promote professionalism, thus ensuring the struggle against inequality, and the fulfilling of the social and cultural role of education, the latter being an individual and collective good, serving each of us, all, and society.
>
> Moreover, educational policy has to be co-ordinated with other social policies particularly in areas such as Labour, Health, Environment, Science, Culture and Internal Administration for several reasons: because of the fundamental importance of the struggle against social and school exclusion, the connections between education-formation and work, the universal character of basic schooling, and because of its unquestionable role in the preparation of citizens.[14] (Governo, 1998)

Key importance is attributed to compulsory education. The latter is perceived as the general educational basis, although its development is not seen entirely independent from market needs and demands.

> Compulsory education constitutes a challenge to which all developing countries pay a great deal of attention; on the one hand, because literacy studies show that only a long, solid, and consistent initial formation ensures that, regardless of the ways of living, there will be no regression in essential knowledge; on the other hand, because compulsory education constitutes the beginning of a lifelong process of education and formation absolutely necessary to respond to personal and social challenges.[15] (Governo, 1998)

Educational Discourses – the Case of Intercultural Education

Contemporary Portuguese education is thus oriented by discourses on lifelong learning, literacy and citizenship education, along with others on the importance of education for economic development. The educational system is centralised, and supported by a National Curriculum. However, there is a significant tendency for change at this level: discussions and proposals for curriculum management flexibility are being developed (Governo, 1998). For example, the 1998 state document *Educação, Integração e Cidadania – Documento Orientador das Políticas para o Ensino Básico* (Education, Integration and Citizenship – Orienting Document for Compulsory Education Policy Making) considers a fundamental guideline espoused by compulsory education:

> The consolidation and stabilising of a common national curriculum, promoting and supporting flexible curricular management and ensuring, in all key stages, that instruction activities and citizenship education are combined in a consistent and permanent form.[16] (Governo, 1998)

Behind the introduction of flexible curricular management one finds discourses on social exclusion, school drop-out, and uneven educational achievement in regional terms. Consequently, in the document quoted above one reads that another essential guideline for compulsory education is:

> To evaluate and develop curricular adaptation experiences, those that primarily intend to prevent exclusion and drop-out, and those which, behind this aim, intend to establish an effective interface with the working world, and also those which intend to ensure intercultural education.[17] (Governo, 1998)

Concern with intercultural education is a characteristic of contemporary Portuguese educational discourse, especially at the compulsory education level (DEB, 1998, Governo, 1998). This trend has a recent history in Portuguese education. It resulted from the state acknowledgement of the increase of the country's cultural diversity after 1974 (Cardoso, 1998, Rocha-Trindade and Mendes, 1993).

The first official recognition of intercultural education dates back to 1991, when the *Secretariado Coordenador the Programas de Educação Intercultural* (Secretariat for the Co-ordination of Intercultural Education Programmes) was created (Ministro da Educação, 1991). This Secretariat, directly dependent on the Ministry of Education, launched in 1993 the most significant state project in intercultural education in Portugal – *Intercultural Education Project* (Projecto de Educação Intercultural). This project involved several compulsory education schools, which were characterised by a high level of cultural diversity among their population (Ministro da Educação, 1993). The project's main focus was a rise in the achievement of students from non-dominant groups (Entreculturas, 1993, Ministro da Educação, 1993, Rocha-Trindade and Mendes, 1993). The project was later expanded, in 1995, and intentions were publicised regarding a further comprehensive and universal expansion (Ministra da Educação, 1995). The latter has not yet occurred.

The understanding of intercultural education by the Portuguese State was expressed in the bill that defined the Intercultural Education Project:

> The general aims of the Intercultural Education Project are:
>
> a) promotion of a kind of intercultural education that allows the Portuguese society a better adaptation to cultural diversity;
> b) development of the relationship between school, family, and local communities;
> c) improvement of equality of access and use of educational, cultural, and scientific benefits;
> d) consideration and appreciation of different kinds of knowledge and cultures in the populations to which the project relates.[18] (Ministro da Educação, 1993, p.8313)

However, the project was limited to a pre-defined group of schools. A major outcome was the improvement of school conditions and the relation between school and community as concluded by the evaluation team - Entreculturas (1995). As previously mentioned, the project had a second phase. This started in the academic year of 1996-1997 and finished by the end of the academic year of 1997-1998. The project knew no further developments. It was not extended to other schools or areas of the country; it remained as a pilot project. In fact, from 1998 onwards, no major state initiative in intercultural education was developed.

Although discussions have taken place concerning the importance of intercultural education in curricular terms (see Barbosa, 1996), on teacher training (see Cortesão and Stoer, 1996, Vieira, 1995), and even on the development of anti-racist education (see Pacheco, 1996), intercultural education in the Portuguese educational system has mostly been presented in terms of guidelines and recommendations, and in terms of independent school practice. No significant change has occurred regarding the state understanding of intercultural education. For example, when defining methodological suggestions about the trend, state discourse considers:

a) the elaboration of class projects within adequate curriculum management;
b) the creation of projects with national and international partners;
c) the promotion of *Círculos de Formação* (Training Groups) within a professional context;
d) the development of action-research projects.[19] (DEB, 1998)

Intercultural education is not an explicit part of the curriculum. It is fundamentally an external aid to situations of crisis regarding cultural diversity. As stated by the Government in a 1998 document on intercultural education, it is a means to

- better accommodate students of foreign origin or nationals with different socio-cultural experiences;

- promote the teaching and learning of Portuguese as a second language, assuming it to be alive and open to change;
- develop processes that directly act on the improvement of the self-esteem, self-confidence and self-image of the 'different';
- share knowledge, values, aesthetic expressions, techniques, and cults of each culture, promoting a reflection on diversity, common dimensions, and existing richness and prejudices;
- develop school work regarding the transmission of the multicultural inheritance embodied in curriculum content, helping young citizens to grow within a framework of interdependency, solidarity, mediation, and active tolerance.[20] (DEB, 1998)

As such, the model of Portuguese intercultural education implicit in the state's educational discourse tends to be one of a remedial nature. It does not involve the whole of the school population and it is very much dependent on school initiative.

Understanding contemporary Portuguese education cannot be set apart from the recognition that mass education is a development of the 1980s. Political change brought educational change. During most of the twentieth century, state education was considered a basic tool for social mobility control via the denial of education to the majority of the population. Contemporary state education in Portugal is the result of a set of internal needs and external demands. Internally, the country needed a literate, skilled and politically educated population so as to develop economically and confirm the democratic process. Externally, joining the EU demanded rapid compensation for years of neglected development. Educational change was perceived as a basic element for that.

In a short period of time, Portuguese education experienced massive transformation, often based on models borrowed from some of its EU counterparts. It suffered the effects of the post-fordist educational developments without even having experienced the fordist ones. Intercultural education was introduced in the country within such a framework. It represents the educational acknowledgement of the cultural diversification of Portuguese society. However, it figures more at the discourse level than at a policy practice one. Responsibility for intercultural education is placed on teachers.

State education includes science education. This educational branch underwent massive development with educational change in Portugal. As understandings of modern science became different so did Portuguese science education. A discussion on science education is the object of the next section. Particular attention will be given to an analysis of Portuguese curricular science education.

6.4 Understandings of Cultural Difference and the Ideology of Modern Science in Science Education

Policy, Aims and General Characteristics of Science Education

Contemporary Portuguese education emphasises science education. This emphasis has only a recent history. During most of the twentieth century, Portuguese state understandings of modern science and education were not favourable to the development of this educational subject. A great deal of Portuguese politics during the last century was defined by an ultra-conservative ideology, which favoured the maintenance of a rural country and economy (Brandão de Brito, 1998, Rosas, 1998).

The industrial boom of the 1960s drew attention to the scientific and technological characteristics of the country (Gonçalves, 1996). However, the development of a well-defined Portuguese policy in modern science and technology is only a result of the 1980s, consolidated in the 1990s with the creation of the Ministry for Science and Technology (Gonçalves, 1996). As late as the 1960s, most of the dominant Portuguese political élite did not recognise modern science as a means for economic evolution. One of the main Portuguese political changes of the late twentieth century regarding modern science was the emergence of such an understanding.

Modern Science Policy and Science Education

At the core of contemporary Portuguese science policy is mainly the belief in scientific and technological development for the country's social and economic change (see for example Gago, 1998b, 2000, Governo, 2001). This new attitude resulted from the Portuguese social and economic backwardness which was attributable to a deficient industrial evolution and associated with the lack of scientific participation in political, social and economic advising and decision making (Gago, 1998b, Governo, 1999).

A change in attitude implied a change in policy. The input given to the promotion and development of *information society* is a good example of that:

> A clear and consistently assumed Government priority is the construction of an Information and Knowledge Society for all, so socially inclusive as competitive, demanding and open. What is at stake is decisive for the country's future. The rapid development of an Information and Knowledge Society is equivalent to the development of indispensable conditions for more qualified work, better living conditions, more competitive and responsible companies, for a better de-bureaucratised, more efficient and transparent public administration, for better health, education and individual formation. Today, the development of a society and economy based in information and knowledge is a national imperative.[21] (Governo, 2001)

Having been under the influence of conservative political discourses on modern science for a long period, Portuguese individual and collective attitudes towards it were consequently mostly characterised by a lack of interest (Gago, 1998b, MCT, 1998). Within contemporary scientific and technological policy one finds attempts to change these attitudes. The basis of such attempts is the belief in the importance of good images of modern science for continuing scientific development. Moreover, such a development is perceived to increase in contexts which are favourable to it. These contexts are those in which modern science is better understood (Gago, 1998b). Thus, the Ministry for Science and Technology defined the development of modern science and technology in association with the following aims:

- making up for backwardness;
- improving quality, reinforcing internationalisation and diversifying partnerships;
- stimulating scientific production;
- consolidating the technological capacity of companies;
- consolidating a new organisation and functioning of the science and technology system;

- implanting science in the country and reinforcing scientific and technological literacy.[22] (MCT, 1998)

Aims for promoting the country's economic and social development were also a characteristic of Portuguese educational discourse of the late twentieth century, as considered in the previous section. So was education for citizenship promotion. Within the resulting educational reform, particular attention was given to the development of science education oriented by aims on sustainable development and promotion of scientific literacy (Governo, 1999, MCT, 1998). This reform affected all educational levels in terms of provision, orientation and curriculum.

Science Education General Aims

Both aims (those of promoting sustainable development and scientific literacy) are encased within discourses of *educational diversification*, *educational democratising*, and *the democratic school*, as defined by Antunes (1996). Both aims involved social, economic and political elements, as regards the improvement of individual life, collective life and political participation. Based on these aims, at the compulsory education level, in practical terms, reform in science education mainly involved:

- the promotion of less formal science teaching and learning, with particular attention given to experimental work, greatly supported by problem-solving and constructivist approaches (supported and defined by the Government) (see Governo, 1999);
- the promotion of science education within a closer relationship with society, as defined by trends such as Science, Technology and Society (see Valente, 1996); and
- the promotion of scientific literacy (see Valente, 1996).

As expressed in the Portuguese Government Plan, the Government will:

- enforce experimental science education at the compulsory education level;
- create centres of Ciência Viva[23], interactive spaces for scientific promotion, in all districts of the country, and it will launch, via the programme Ciência Viva, a regional network for experimental learning of science;
- promote a national programme for supporting experimental science teaching and learning in compulsory education.[24] (Governo, 1999)

Modern Science in Compulsory Education

Within contemporary Portuguese compulsory education, scientific subjects are introduced in all key stages. These include physics, chemistry and biology, which are the subjects that will be analysed in the thesis.

Modern Science in Key Stage 1

Modern science[25] is studied in the educational area *Estudo do Meio* (Study of the surrounding environment). Key Stage 1 is organised by Thematic Areas. This organisation by area is characteristic of the four years that comprise this key stage. There are no defined recommendations about the time to be spent with this area. It is defined by the following themes:

1. Discovering oneself
2. Discovering others and institutions
3. Discovering the natural environment
4. Discovering interrelations between spaces/environments
5. Discovering materials and objects
6. Discovering interrelations between nature and society (Ministério da Educação, 1990)[26]

Each section is designed with a problem-solving orientation, and within a constructivist framework (Ministério da Educação, 1990). Lessons on physics, chemistry, biology, and on the interaction between them and societies are introduced particularly in themes 3, 5, and 6.

Modern Science in Key Stage 2

Science education appears in this key stage in the subject *ciências da natureza* (sciences of nature), which occupies three hours per week during each year. This subject mainly involves geology and biology. It is also problem-solving oriented and based in a constructivist approach (DGEBS, 1991b).

Modern Science in Key Stage 3

Science education is dealt with in the subjects: *ciências naturais* and *ciências físico-químicas* (natural sciences and physics and chemistry). Natural sciences mainly involve biology. It is taught during the first two years of the key stage. During Year 1, the subject is taught for four hours per week. During Year 2, it is taught for three hours per week. As for physics and chemistry, these subjects are taught during the last two years of the key stage, being allocated to it four hours per week during Year 2, and three hours per week during Year 3. The physics component is organised in thematic areas, and the chemistry component is organised by content areas.

The organisation of the physics component of Years 2 and 3 of Key Stage 3 is as follows:

- Thematic Area A – Us and the universe
- Thematic Area B – Power production, distribution, and use
- Thematic Area C – Sound and listening
- Thematic Area D – Light and vision
- Thematic Area E – Energy production and consumption
- Thematic Area F – Transport and security
- Thematic Area G – Radiation and the environment
- Thematic Area H – Controlling and regulating
- Thematic Area I – The atmosphere and weather changes[27] (DEB, 1995)

Thematic areas from A to D are taught in Year 2 of Key Stage 3 and they are compulsory. The remaining areas are taught in Year 3. Areas E and F are compulsory. From areas G to I, the school/teacher chooses one thematic area for teaching. The title of each area summarises the issues involved therein. The study of physics is developed within a set of problems and current situations. These are summarised in a central question posed by the students and the teacher. There is also a suggested question presented in the curriculum (DEB, 1995). The study of physics concepts is developed within a framework of problem-solving and Science, Technology and Society, focusing on the development of scientific literacy (DEB, 1995). The separation between compulsory and optional areas was defined as a means to secure a common formation for all students, and the possibility to study issues which may be more relevant in some schools than in others (DEB, 1995).

Although content areas of the chemistry component of Key Stage 3 are not subjected to a theme, the approach is the same as that of the physics component: problem-solving, and Science, Technology and Society, with great emphasis on the development of scientific literacy. For Year 2 of Key Stage 3 the following content areas are considered:

1. Us and the material environment
2. Chemical substances: what are they, and what one does with them?
3. Chemical transformations and our surrounding environment[28] (DEB, 1995)

For Year 3:

1. The constitution of matter in more detail
2. Chemical transformations and our surrounding environment
3. Organisation of chemical elements and diversity in chemistry
4. Chemistry and its impact in society: a first retrospective[29] (DEB, 1995)

All content areas are compulsory. Regarding both subjects, (i.e. natural sciences and physics and chemistry) during this key stage, the number of hours per week attributed to science education by year is:

- Year 1: four hours/week
- Year 2: seven hours/week
- Year 3: three hours/week

Final Elements

Compulsory science education in Portugal, particularly regarding biology, physics, and chemistry, is strongly emphasised. Considering the number of hours attributed to these subjects in Key Stages 2 and 3, and comparing them with other subjects such as Portuguese and mathematics (Porto Editora, 1998, p.70) one finds the following:

Key Stage 2

Subject	Year 1	Year 2
Portuguese	five hours/week	five hours/week
Mathematics	four hours/week	four hours/week
Sciences of nature	three hours/week	three hours/week

Key Stage 3

Subject	Year 1	Year 2	Year 3
Portuguese	four hours/week	four hours/week	four hours/week
Mathematics	four hours/week	four hours/week	four hours/week
Natural sciences	four hours/week	three hours/week	
Physics and chemistry		four hours/week	three hours/week

Science education was strongly developed on account of changes in political understandings of modern science for Portuguese society. Modern science, particularly biology, physics, and chemistry, is considered in compulsory education from Key Stage 1. It evolves within a continuing line and under the same orientation. This orientation is mainly based on constructivist models, problem-solving approaches, and the promotion of scientific literacy.

General and specific objectives are defined for each key stage. They represent what is expected from the student at the end of each key stage. Consequently, the general and specific objectives for Key Stage 3 represent what is expected from a student at the end of nine years of compulsory education. The National Curriculum not only involves general and specific objectives, but also defines content and methodological suggestions. Objectives, content and methodological suggestions will be the object of the following curricular analysis.

Curriculum Analysis

Data Presentation and Analytical Discussion

The curricular analysis focuses on the analyses of biology, physics and chemistry:

1. Curriculum orienting conceptual framework; and
2. Curriculum content characteristics.

As considered in Chapter 5, Section 5.3, data will be organised under the headings:

1. Modern science as the metanarrative on the natural world
2. Scientific means of reasoning as the means of reasoning
3. 'West' and progress/sustainable development

Analyses are considered along with the data presentation. Basically, the analyses will identify and discuss the eventual presence of the ideology of modern science in the science curricula. Results of the analyses will later be presented as answering elements to the posed research questions.

Modern science as the metanarrative on the natural world

Curriculum orienting conceptual framework

Key Stage 1
Study of the surrounding environment curriculum

Within the general objectives for this Key Stage no explicit reference is made to modern science as *the* metanarrative on the natural world. This is also the case regarding specific objectives. However, certain use of language in the specific objectives may be seen as involving implicit understandings of modern science as *the* metanarrative on the natural world. Phenomena, as considered in and explained by modern science, tend to be presented in the form of *truth*. For example, within the theme *Discovering the natural environment*, part of Year 4, one finds specific objectives such as:

> Recognising and observing phenomena:
> - of condensation (clouds, fog, dew)
> - of solidification (snow, hail, frost)
> - of precipitation (rain, snow, hail)[30] (Ministério da Educação, 1990, p.82)

The scientific explanation for the phenomena presented is implicitly given in the form of *the* answer. For example, clouds *are* a phenomenon of condensation.

Key Stage 2

Sciences of nature curriculum

Under the heading 'Intellectual aptitudes and cognitive strategies' one reads the following objective:

> To apply elementary operational notions of space, time and quantity (number, proportionality, distance, and linear time, ...) to the perception and interpretation of facts and concrete situations[31]. (DGEBS, 1991a, p.31)

The objective involves notions of space, time, and quantity as scientifically defined. Through the nature of its form and the use made of language, it is possible to consider that it may be promoting the acceptance of such scientific notions as *the* true ones. Moreover, since the objective is comprehensive to all subjects of Key Stage 2 (DGEBS, 1991a), it implies stress on that promotion. Notions of space, time and quantity as scientifically defined are expected to be used in fields other than that of modern science as the objective is common to all subjects of Key Stage 2. The perception and interpretation of facts and concrete situations in whatever subject is expected to be done by making use of scientific concepts. It is possible then to consider that scientific knowledge is the one that provides *the* explanation not only in relation to the natural world but with regard to the social world as well. One can find in this objective the presence of the ideology of modern science: the latter as the metanarrative on knowledge of the natural and the social worlds.

Another example of the tendency to value modern science as *the* explanation of the natural world is given by the following aim defined for Year 1:

> To understand the importance of biological classification as the means of organisation and systematising of diversity among living beings.[32] (DGEBS, 1991b, p.9)

Classification is an intellectual skill which is perceived fundamental within the scientific methodology. It tends to be associated with the notion of scientific means of reasoning. Such a skill appears in this objective as *the* way for explaining diversity among living beings. Within the ideology of modern science, scientific means of reasoning are understood as *the* means of reasoning. Explanations obtained by making use of scientific means of reasoning are then *the truth*. As the objective above considers biological classification as *the* means of organising and systematising diversity, the resulting classification will be *the truth*. One finds the ideology of modern science in the objective above with regard to the understanding of scientific means of reasoning as *the* means of reasoning, and implicitly, one also finds the ideology of modern science in terms of the understanding of scientific knowledge as *the* explanation.

Within the heading 'Attitudes' one finds another possible example of the understanding of modern science as the metanarrative on the natural world.

> To reveal attitudes of respect and solidarity towards people of different age, gender, race, and social origin, as well as towards those from other cultures, appreciating their traditions, products of expression and technology.[33] (DGEBS, 1991a, p.34)

This objective implies recognition and respect for diversity in different terms. Reference is made to technology. The latter is perceived differently within different cultural groups. Different cultures are seen as developing specific traditions, forms of expression and specific technological applications of scientific knowledge. Yet, as no explicit reference is made to modern science or other forms of science, it is possible to consider that this objective implies the notion of modern science as beyond culture. Modern science is not explicitly presented as a cultural element in the sense that it may have been developed specifically by one culture and thus, that it may be a characteristic of such a culture. This being the case, a possible implication of the objective above is that of the implicit promotion of modern science as the metanarrative on the natural world. This is a fundamental basis of the ideology of modern science. Consequently, within this framework, one can assume the presence of the ideology of modern science in the objective above.

The objective is comprehensive for all subjects within this Key Stage (DGEBS, 1991). This means that regardless of the subject that will be studied during the Key Stage the image of modern science that is being promoted is very possibly one based on the ideology of modern science. Consequently, one may assume that the ideology of modern science may not only be present in terms of science education, but it may be present in other educational subjects of this Key Stage.

Key Stage 3

Natural sciences and physics and chemistry curricula

Regarding the general objectives for this Key Stage, and similarly in the case of Key Stage 2, under the heading 'Intellectual aptitudes and cognitive strategies' one finds the following objective:

> To apply operational notions of space, time and quantity (number, function, velocity, temporal multiplicity,...) in the organisation and interpretation of knowledge data.[34] (DGEBS, 1991a, p.36)

Similar arguments to those presented regarding a similar objective for Key Stage 2 in pages 176-7 can be made in relation to this one. Likewise, it is a common objective to all subjects of Key Stage 3 (DGEBS, 1991a, p.36).

Again, similarly to the discussion put forward regarding Key Stage 2 on page 178, different forms of scientific knowledge production are not explicitly considered within a framework of cultural diversity. This is the case of the following objective, which is part of the 'Attitudes' group. The objective is comprehensive to all subjects of the Key Stage (DGEBS, 1991).

> To demonstrate comprehension and solidarity to nations, groups, and people, appreciating cultural differences (practices, traditions, artistic expressions, technologies,...) and denouncing discriminating and unfair attitudes.[35] (DGEBS, 1991a, p.40)

Considering in particular the physics and chemistry curriculum one reads the following objective:

> In its scientific dimension, the subject of Physics and Chemistry must promote the acquisition of concepts, laws, theories, and models characteristic of Physics

> and Chemistry needed for the global comprehension of the Universe and of the surrounding world (...).[36](DEB, 1995, p.8)

In this objective, physics and chemistry are understood in terms of theories and laws. Yet, at the same time, they are considered as *the* explanation. This is particularly expressed by the use of the definite article *the,* and not *a* in the expression: 'the global comprehension of the Universe and of the surrounding world'. The mentioned concepts, laws, theories, models can be understood as elements of *the* explanatory paradigm and not of one specific explanation.

Within the aims for this subject one reads:

> To stimulate interest, curiosity and cherishing, among the youth, for the study of natural phenomena and for the interpretation of the physical environment in which they are integrated.[37] (DEB, 1995, p.9)

Again modern science may be perceived as *the* metanarrative. This aim does not seem to involve a consideration of modern science as a possible explanation, but as *the interpretation* of the natural world. Concepts, laws, theories and models may be used to make possible interpretations of the natural world. Yet, in the objectives above, there seems to be an implication that there is only one interpretation of the natural world and this is the one provided by modern science via its theories, concepts and models. One can find then the ideology of modern science in the two objectives above. Consequently, one may consider that they may contribute to the transmission of an image of modern science as the explanation of the natural world and not as the scientific explanation of such a world.

This seems to be also the case of the following objectives for Year 2, chemistry content area 2:

To infer on the very small size of matter's constituting corpuscles.

To distinguish matter's physical states in terms of corpuscular aggregation.[38] (DEB, 1995, p.54).

Corpuscular theory of matter is presented as *the* explanation for the nature of matter since the objectives above do not mention it as a theory. Moreover, the objectives do not even reflect the various possibilities that the theory in which they are based involves. For example, the first quoted objective can be seen as implicitly proposing an inference in terms of the size of individual particles, assuming that they are physically existing entities. This ignores the mathematical constructs supporting the notion of particle or the energy particles such as the photon, which do not have mass.

The objectives above present aspects of corpuscular theory detached from the theory itself and the explanation of particular phenomena such as matter's physical states. As aspects of a scientific theory are presented as *the* explanation for particular phenomena, one can consider the presence of the ideology of modern science (modern science as the metanarrative on the natural world) in the objectives above. Similar objectives are found for chemistry content area 1, Year 3 'The constitution of matter in more detail', which constitutes an extension of content area 1, Year 2 (DEB, 1995).

Natural sciences curriculum

Similarly to what has been discussed above, within the specific objectives for this subject one can find again the implicit idea of scientific explanations as the definitive explanations. For example:

To understand that Earth belongs to a planetary system dependent upon the Sun.

To identify the solar system as a part of the Universe.[39] (DGEBS, 1991c, p.9)

Again, the use of language is important. No mention is made of theories or principles. The objectives can be understood as describing statements to be taken as *the truth.*

The objectives present aspects of theories and thus, of explanations. However, such theories, as all others, not only are of a temporary nature, but also the existence of a theory that may be final is a fundamental point of discussion in philosophy of science and among scientists themselves. Objectives such as the above, can be seen as ignoring such important aspects of the nature of modern science. They present scientific knowledge in a simplified and deterministic manner as theories, or parts of theories, appear to be *the* answer to particular questions about the natural world. This is a characteristic of the ideology of modern science. Once again, one can detect its presence in the objectives above.

The various examples presented in this subsection point out a permanent and continuing presence of the ideology of modern science, in terms of the image of modern science as *the* metanarrative on the natural world, in all of the three Key Stages. Most of the elements involved in such a presence are of an implicit nature. They tend to be presented by a use of language that is statement/affirmative-based. References to models and theories are very seldom made. When such references are made, they generally do not contest the nature of modern science as the explanatory paradigm. They tend to imply continuing changes in the type of explanatory answers, but they do not question the *true* nature of such a kind of answer.

Overall, the examples discussed above do not take into account basic discussions on the nature of modern science. They do not consider the limits of the latter; they do not consider the fundamental discussion of the existence of a theory that will be capable of being *the* explanation of the natural world. Moreover, as some of the examples that were considered are comprehensive to all subjects of the various Key Stages, one can infer that possible transmissions of a particular image of modern science, which considers it as the metanarrative on the natural world, may be occurring in school subjects other than science education.

Curriculum Content Characteristics

Key Stage 2

Sciences of nature curriculum

Within the sciences of nature curriculum, particularly regarding Year 2, one finds a tendency to emphasise the development of a scientific concept of life as *the* concept of life. Associated with this concept is generally that of health. Health is mostly presented within a scientific framework, which can be seen implicitly taken as *the* framework. Health is not considered context-based regarding cultural differences. For example:

> To recognise the interaction between the different systems in the organism unity.
> To understand concepts of human morphology and physiology, which are necessary for the understanding of health problems.[40] (DGEBS, 1991b, p.20)

The objectives above consider life in terms of the notion of 'organism'. This notion derives from a mechanistic approach of understanding the natural world, which is a characteristic of modern science. Within such an approach, parts of 'the whole' are separated so as to be studied and understood. Human morphology and physiology are parts of the individual, in this case taken as an organism. The concept of health within such a framework directly relates to human morphological and physiological conditions. Such an understanding of both concepts of life and health leave behind fundamental cultural aspects which define individual existence and well-being. They constitute particular scientific understandings of life and health. However, the objectives above do not present them as such. For example, 'concepts of human morphology and physiology are necessary for *the* understanding of health problems' not for 'an understanding' or even for 'understanding health problems'. The objectives can then be seen as embodying the idea of modern science as the explanatory paradigm, and consequently, the ideology of modern science.

Key Stage 3

Natural sciences curriculum

Similar to the examples discussed above for Key Stage 2, regarding the natural sciences curriculum for Key Stage 3, one can also find understandings of scientific explanations of life, and particularly of the human body and health, implicitly presented as *the* definitive explanations. The bases of the natural sciences curriculum for Year 2 are defined as:

- Vital functions involve cellular renovation processes, energy use, material transport, and the elimination of damaging products.
- The neural-hormonal system ensures the co-ordination of all vital functions, which are essential to life.
- Human reproduction involves specific biological processes and implies responsibilities which have to be known.[41] (DGEBS, 1991c, p.23)

A similar interpretation to that put forward for previous examples - pages 182-3 - can be considered here. Again, the use of language is very significant. Content tends to be expressed in a statement/affirmative basis, which can imply the universalising of the concepts at issue. Moreover, in this objective, human reproduction is considered. Yet there is no clear mention of what are the 'responsibilities which have to be known'. Human reproduction seems to be fundamentally considered within the framework of modern science and consequently in association with scientific understanding of life, leaving behind other understandings such as cultural ones. This is again the case in the following methodological suggestions:

> Research on means of contraception constitutes a direct application of notions of physiology. Particular emphasis has to be given to the need to respect the calendar implied by hormonal methods. In birth control, which is the object of contraception, one must emphasise the sense of and respect for life and individual and social responsibilities.[42] (DGEBS, 1991c, p.28)

In this suggestion, human reproduction is perceived mainly in biological terms. References to social and individual factors are also considered. However, no explicit reference is made of cultural ones. Moreover, no reference to a discussion of the concept of contraception is considered.

The concept of life presented in the science curricula for Key Stages 2 and 3 is a scientific one. No references are made to other understandings of life. Concepts of health and contraception are discussed within such a framework. Scientific notions are presented in the curricula as *the* explanations. One can then consider that the examples that were discussed reflect the presence of the ideology of modern science in the sciences of nature and natural sciences curricula.

Physics and chemistry curriculum

Physics component

With Thematic area A – *We and the universe* - students are expected to learn the scientific interpretation of the universe. Yet, one does not find any mention of the notion of interpretation (DEB, 1995). Theories on the universe can then be assumed as *the* explanation depending on how they are presented. This is also the case in Thematic area I – *Atmosphere and weather changes* (DEB, 1995). Likewise, for example, in the Thematic area G – *Radiation and the environment*, one finds the following terms under content:

We live immersed in an 'ocean' of radiation originated from the Sun, space (...) [43](DEB, 1995, p.68).

One does not find references to notions of theory, model, and interpretation in any of the thematic areas (DEB, 1995). One does not find any historical references either as regards the development of the several scientific theories involved (DEB, 1995). There seems to be hardly any elements on the nature of scientific knowledge in the various thematic areas. The scientific knowledge involved is mostly presented as *the* knowledge. Moreover, the use of thematic areas can be understood as implicitly stressing the understanding of modern science as the explanatory paradigm on the natural world. This is so, because within each thematic area modern science is mostly considered in relation to daily life activity and observed natural phenomena. So scientific explanations may more naturally become *the* explanations. For example, the wave model used to explain sound and light (DEB, 1995) – Thematic areas C and D - can become naturally accepted as *the* answer. That is, sound and light *are* waves, and not that scientifically, sound and light are waves. The ideological notion of modern science as the explanation is again reflected in these examples.

Chemistry component

As with the physics component, in this one, hardly any reference is made to the nature of modern science. For example, in Content area 2, Year 2 – *Chemical substances: what are they and what one does with them* – one reads:

After remembering, through experimental work, that matter is constituted by permanently moving corpuscles (...).[44](DEB, 1995, p.17).

This sentence exposes the implicit ideological understanding of modern science that has been discussed: corpuscles constitute matter. Corpuscular theory is presented as the explanation for the nature of matter and not as the scientific explanation. Moreover, experimenting is proposed as a means to prove it. Experimentation may allow the support for models but it grants no proof of the nature of matter, particularly at the level of school science. In this objective not only are aspects of theory presented as *the* answer, but also experimentation is proposed as proof for such an answer when it should be considered as an indicator of the likelihood of the theory at issue. The objective above is embedded in the ideology of modern science in terms of the understanding of the latter as the provider of final explanations. Moreover, the objective makes use of the notion of experimentation as a supporter of the ideological notion of modern science as the metanarrative on the natural world: experimentation as a means to prove that moving corpuscles constitute matter.

This same idea is expressed at the level of Content (Year 2, Content area 2):

> How substances are constituted.
>
> Matter's corpuscular nature.
>
> Aggregation and corpuscular movement.[45] (DEB, 1995, p.54)

There are no references to models or theories. Corpuscular theory appears as the truth. The first point in the contents above considers the nature of matter. The second and third ones present the answer: corpuscles, aggregation and movement. No references are made to a corpuscular theory of matter. This is also the case in Year 3, Content area 1, which constitutes an extension of Content area 2, Year 2.

Regarding Content area 1, Year 3, within the methodological suggestions one finds a particular case regarding the abandonment of an historical approach to corpuscular theory. This is justified by the eventual introduction of misunderstandings on what is considered to be the *correct* model (DEB, 1995).

> A correct visualising of the atom should be enforced instead of the study of theoretical models of historical interest.[46] (DEB, 1995, p.75)

Consequently, one can argue that implicit in the transmitted knowledge is the idea of a model as the explanation. The historical approach to corpuscular theory or to any other theory allows the study of the nature of theories. It allows the study of several of the ways by which scientific knowledge is produced, ideas change and theories are replaced. In the content above, the historical approach is seen as making it difficult to learn the 'correct visualising of the atom'. But the question is what is the correct visualising of the atom? The content above is not only excluding the possibility of studying the nature of scientific knowledge, but it is also proposing the study of a model, which is itself changing, as *the true* model. The content is embodied in the idea of aspects of the corpuscular theory of matter as *the* explanation for the nature of matter. One finds then the ideology of modern science embodied in the content above.

In this same Content Area one also reads:

> In this thematic unit a first incursion into the microphysical world is made, particularly concerning matter at the level of the structure of molecules, atoms, and respective aggregates, in relation to certain properties. One starts to find answers to questions such as 'how are material things "inside"?'[47] (DEB, 1995, p.18).

Modern science is explicitly portrayed as *the* provider of answers. One does not find references to the nature of such answers: are they final, provisional or possible answers? This is again the case in Content Area *Us and the material world* (Year 2). Within the defined content for this area one finds the following statements:

> Chemistry as the answer to questions about the material world.
> Chemistry is a fascinating science.
> First experiments and observations in chemistry.
> The questions answered by chemistry.
> Chemistry and Man and Society's demands.[48] (DEB, 1995, p.50)

Chemistry is presented as the provider of answers but no references are made to the nature of such answers. Moreover, chemistry is presented as the provider of *the* answers to the material world. It appears as a part of the metanarrative on the natural world. One finds then the ideology of modern science in the statements above.

In terms of content and methodological suggestions, in Key Stages 2 and 3, examples of the presence of the ideology of modern science regarding understandings of modern science as *the* final metanarrative on the natural world were found. Theories such as the corpuscular one tended to be presented as *the* explanation. Explicit references to notions of theory, model or interpretation were hardly ever found.

These results are similar to those obtained in the discussion of the curriculum conceptual orienting framework. One can then argue for an internal coherence in the curriculum regarding the understanding of modern science as the metanarrative on the natural world. In this respect, the whole curriculum can be seen as subscribing to the ideology of modern science.

Scientific means of reasoning as the means of reasoning

Curriculum orienting conceptual framework

Key Stage 1
Study of the surrounding environment curriculum

Among the general objectives for this Key Stage, under the heading 'Intellectual aptitude and cognitive strategies', one reads:

- To carefully observe facts so as to understand them, correcting perceptive intuitions.
- To record and organise facts, objects and situations through their serial organisation and classification.
- To identify properties, dissociating data from the concrete experience, and to make simple generalisations in delimited situations.
- To establish little reasoning chains so as to solve problems, enunciating the followed steps.
- To explain new situations, concrete and close to his/her experience, through careful observation and the establishment of associations and similarities.[49] (DGEBS, 1991a, pp.8-9)

These objectives relate to the development of scientific means of reasoning, and to intellectual skills associated with the scientific methodology. They are not exclusive to the area *Study of the surrounding environment*. They relate to the whole of Key Stage 1. Implicit in the nature of these objectives can be seen an understanding of the scientific methodology as *the* means of reasoning, once other means of reasoning are omitted and disregarded. As the objectives are comprehensive to all subjects in Key Stage 1, one may argue that implicit in them can be found the ideological notion of scientific means of reasoning as *the* means of reasoning regardless of the object of study.

Within the orienting guidelines of the *Study of the surrounding environment* curriculum, one can also find the influence of the ideology of modern science regarding the importance attributed to the scientific methodology. One reads that

> In order to master the concepts it is not necessary that all students follow the same paths. However, it is intended that all of them become active observers with a capacity to discover, investigate, experiment, and learn.[50] (Ministério da Educação, 1990, p.68)

The importance attributed to the scientific methodology as a means to find answers is expressed in the titles of each section of the *Study of the surrounding environment* curriculum. The title of each section starts with the word *discovering* (see page, 167, in this chapter). This is in accordance with a problem-solving approach, which is embodied in the whole curriculum. Such an approach generally subscribes to a study of reality based on scientific methods. This may stress the idea of the value of the scientific methodology as *the* methodology for understanding reality, regardless of its nature.

Key Stage 2

Sciences of nature curriculum

Emphasis is again given to the scientific methodology in the specific objectives for this subject. This is the case of the following objectives defined for Year 1:

> To reveal the capacity to observe and to order observations.
> To interpret data and reach conclusions.
> To reveal the capacity to learn how to think.[51] (DGEBS, 1991b, p.9)

The ideology of modern science regarding the scientific methodology is rather expressed in the last of the quoted objectives. *Thinking* can be seen as presented as an acquired skill or group of skills that can be learned, which is in direct relation to scientific means of reasoning.

Under the heading 'Intellectual Aptitudes and cognitive strategies' one can find once more the ideology of modern science in the following objectives:

- To apply elementary operational notions of space, time and quantity (number, proportionality, distance, and linear time, ...) in the perception and interpretation of facts and concrete situations.

- To generalise from groups of simple data so as to determine rules and proprieties.
- To respect the basic procedures of deductive logical reasoning in problem solving.
- To justify procedures and conclusions, based on knowledge, fact and experimental or documented data.
- To interpret new situations of concrete nature and close to his/her experience, with association and comparison to situations already known.[52] (DGEBS, 1991a, pp.8-9)

Similarly to the case of Key Stage 1, the general objectives considered above can be seen in a direct relation to the scientific methodology. They express a deepening in the development of intellectual skills associated with such a methodology in relation to the previous Key Stage. Moreover, explicit reference is made to the deductive method in terms of respect for it. No other methods are mentioned. Also, regarding the general objectives of Key Stage 1, one can argue that in their nature there seems to be implicit the ideological notion of the scientific methodology as *the* methodology.

Moreover, these objectives are not exclusive to the subject *Sciences of nature*. They apply in all Key Stage subjects. Thus, they refer to subjects such as religious education and personal and social formation (DGEBS, 1991a, p.31). Teachers are expected to promote the use of scientific means of reasoning in subjects other than science education such as those indicated above, or others like history and geography. One can argue that implicit in these objectives is then the ideological belief of the importance of the scientific methodology as *the* means of reasoning in general, not only in relation to scientific knowledge production.

Key Stage 3

Natural sciences and Physics and chemistry curriculum

Once more, under the heading 'Intellectual aptitudes and cognitive strategies' regarding the subjects Natural sciences and Physics and chemistry one reads:

- To apply operational notions of space, time and quantity (number, function, velocity, temporal multiplicity,...) in the organisation and interpretation of knowledge data.
- To carry out rigorous observations, using the procedures required by the different areas of scientific knowledge, so as to analyse and interpret facts.
- To infer rules, properties, and general relations from the analysis of facts and situations.
- To infer the consequences to principles using deductive reasoning in problem-solving, simple mathematical demonstrations, and hypothesis verification.
- To apply concepts, generalisations, theories and models for explaining and exploring situations, phenomena, and processes related to different dominions of reality.[53] (DGEBS, 1991a, pp.8-9)

After the end of compulsory education, students are expected to have developed the foundations of the scientific means of reasoning. This development is understood in a comprehensive way. Skills and aptitudes characteristic of scientific methods are not related exclusively to science education. Nor is a problem-solving approach. Once more, the objectives above are comprehensive for all subjects of all Key Stages (DGEBS, 1991a, p.31). Similar arguments to those made regarding Key Stage 2 can thus be made (see pages 189-90).

Physics and chemistry curriculum

Within the introduction to the Physics and chemistry curriculum one reads:

> In its scientific dimension, the subject of Physics and Chemistry must promote the acquisition of concepts, laws, theories, and models characteristic of Physics and Chemistry needed for global comprehension of the Universe and of the surrounding world, and the processes which are intrinsic to such a comprehension. Among those, one finds the search for causal relations,

> experimentation, quantified description, the explanation of results obtained through observation and experimenting, deduction of the consequences of a theory, the prediction of results based on hypotheses, experience planning to test ideas, judgement making on (direct or indirect) measurement, or the analysis of experimental data.[54] (DEB, 1995, p.8)

This paragraph shows the importance attributed to scientific methodology as a means of finding global explanations regarding the *Universe* and the *surrounding world*. It can be seen as another example of the presence of the ideology of modern science in the science curriculum.

Within the Chemistry component, one detects once again the importance of scientific methodology as the means of reasoning in objectives such as:

> To recognise the importance of observation and experimenting associated with reflection and development of ideas.[55] (DEB, 1995, p.50)

The development of scientific means of reasoning as *the* means of reasoning, applying to knowledge fields other than the scientific, is expressed in the general objectives for all compulsory education. Several of the general objectives, such as those discussed in pages 189 and 190, are the objectives for most subjects of Key Stages 2 and 3.

Emphasis is put on a problem-solving approach, which is not exclusive to the science education curriculum. There is an emphasis, defined in terms of respect, on the deductive method. Consequently, one can argue for the presence of an implicit association of the scientific methodology with the ideological notion of the latter as *the* means of reasoning.

Curriculum content characteristics

Key Stage 1

Study of the surrounding environment curriculum

In this curriculum, great emphasis is placed on a problem-solving approach. This involves the promotion of the development of scientific means of reasoning and a stressing of its importance. Consequently, in the introduction of the theme *Discovering the natural environment*, one reads:

> Children's curiosity for natural phenomena should be stimulated, and students should be encouraged to raise questions and search for answers through experiment and simple research. The conducted studies will have direct observation as their basis, making use of all senses, sample collection, safeguarding the environment, and experimenting. (...) It is important, that from the beginning, students record all that is observed.[56] (DGEBS, 1991a, p.79)

The scientific methodology is once more emphasised in the theme *Discovering materials and objects*.

> (...) With this block one intends to develop an attitude, among the students, of permanent experimenting with all that it implies: observation, introduction of modification, analysis/understanding of effects and results, conclusions.[57] (Ministério da Educação, 1990, p.87)

Emphasis is also given to the skill *classification*. This appears to be presented as *the* means to understand diversity regarding materials and living beings.

> To compare materials according to some of their properties (flexibility, resistance, solubility, hardness, transparency,...)
> To group materials according to such properties.[58] (Ministério da Educação, 1990, p.88)

To compare and classify plants according to criteria such as: colour of the flower, shape of the leave, (...).

To compare and classify animals according to their external characteristics and ways of living.[59] (Ministério da Educação, 1990, p.81)

Key Stage 2

Sciences of nature curriculum

Following the development of the skill *classification* initiated in Key Stage 1, Year 1, Key Stage 2 is particularly focused on the classification of living beings. This tends to be presented as *the* means to understand diversity among living beings. The definition of classification criteria and their application as *the* means of understanding diversity tends to be emphasised as well. Although no specific reference is made to human beings, there is a danger of an extension of means of classification in relation to the latter ones, as there seems to be a tendency to transmit the notion of this skill as *the* way to understand diversity. Even when perceived as an analytical instrument classification is often taken as a universal one.

Classification of living beings.

Importance of classification

How to classify living beings.[60] (DGEBS, 1991b, p.15)

Key Stage 3

Natural sciences curriculum

As was the case in Key Stage 2 with the Sciences of nature curriculum, so here one can also find an emphasis on classification as *the* means of understanding diversity among living beings, particularly in Year 1 (DGEBS, 1991c). Among the methodological suggestions one reads the following:

Elaboration of classification keys regarding the diversity of relations among living beings, indicating the criteria used.[61] (DGEBS, 1991c, p.18)

Physics and chemistry curriculum

Chemistry component

Within this component there is a great concern with the development of categorisation and classification techniques (DEB, 1995). More importantly however, is the associated notion of the fundamental need for such means of organising information. This is particularly the case with Content area 3, Year 3 – *Organisation of chemical elements as a response to diversity in chemistry.* The means of classification used are mainly of a dual nature, defining difference in terms of opposition. For example, metals/non-metals (DEB, 1995, p.82).

Through all Key Stages, emphasis is given to scientific methods. Within the problem-solving approach that characterises each subject, scientific methods are generally presented as the definitive methods. Particular attention is given to the skill classification. This is presented both in biology and chemistry mainly as the means to organise and understand diversity. These results are similar to those put forward regarding the analyses of the curriculum conceptual orienting framework. Thus, it is plausible to argue that in the whole curriculum one can find the ideology of modern science regarding understandings of scientific means of reasoning as the means of reasoning.

'West' and progress/sustainable development

Curriculum orienting conceptual framework

Key Stage 2

Sciences of nature curriculum

> To recognise the value of scientific and technical advancements for the progress of human societies [62](DGEBS, 1991a, p.34).

This objective is not only part of the sciences of nature curriculum. It is also considered in history and geography of Portugal, mathematics, visual and technological education, and personal and social formation[63]. The objective omits a definition of human societies and the cultural, social and economic elements eventually associated with them. It is quite general and it can be understood as implicitly universal. The concept of progress is associated with that of scientific and technical advancements. No reference is made to the possible negative consequences of such advancements. In fact, no reference is made with regard to the effects of such advancements in different kinds of societies. There seems to be an implicit message in the objective above: one that sees universal positive societal development via scientific and technological evolution. This is an element of the ideology of modern science. One can then see the latter as implicit in the objective above.

The concept of progress involved in the ideology of modern science is one that is associated with 'Western' cultural supremacy, as it was discussed in Chapter 2, sections 2.3 and 2.4. Questioning this concept of progress implies questioning such 'Western' cultural supremacy. This same concept of progress can be seen in the objective above, as discussed in the previous paragraph. As no questioning of such a concept can be found in the objective, one can infer that no questioning of 'Western' cultural superiority associated with scientific and technological progress is being considered. One can thus argue that the objective, via its embodiment in the ideology of modern science, may contribute to the transmission of notions of 'Western' cultural superiority due to progress associated with scientific and technological development.

Further on in the curriculum one finds the following objective:

> To understand the implications of science in everyday activities of human life.[64]
> (DGEBS, 1991b, p.9)

These implications relate to issues of health and pollution. Yet, one does not find any specific recommendation for de-constructing of notions of progress (DGEBS, 1991b). Whose 'human life'? Where on the planet is 'human life' considered? Which everyday activities? One does not find a reflection of any of these questions in the objective above. It is as though human life and everyday activities were the same for every individual, and all of these activities were directly related to scientific and technological development in the same manner. Both this objective and the one discussed immediately before are de-contextualised in the sense that they not make explicit the societies at issue. Certainly scientific and technological development is perceived differently and is affecting differently Western European societies and African societies, for example. Yet, in the objectives above, progress may be considered in a universal and positive framework as it is claimed by the ideology of modern science.

Key Stage 3

Physics and chemistry and natural sciences curricula

Physics and chemistry curriculum

Within the general objectives for Key Stage 3, one reads the following objectives regarding physics and chemistry in particular:

> To master basic knowledge of physics and chemistry that is necessary for the scientific interpretation of physical phenomena and important technological aspects in contemporary society.
>
> To master basic knowledge of physics and chemistry, that is necessary for well-informed daily acting regarding the use of technology and decision-making in terms of use and consumption that may affect local and global communities.
>
> To recognise the importance of contributions from physics and chemistry to the improvement of the quality of life.[65] (DGEBS, 1991a, p.38)

In these objectives, physics and chemistry seem to be presented as fundamental for the improvement of the quality of life, for the understanding of the natural world and for decision-making in daily life. Physics and chemistry are thus, generally presented as a fundamental and global means of progressing individually and socially. Once again, it is not clear which societies are involved and what progress would mean for them and in each of them. The notion of a universal progress in the dependency of modern science, which is part of the ideology of modern science, can again be found in the objectives above as well as in the following one:

> To value the contribution of scientific and technological development for the historical progress of societies, critically analysing the implications of such development in contemporary society[66] (DGEBS, 1991a, p.39).

In this objective modern science's contribution to progress is considered within an historical perspective. However, scientific knowledge, as it is contemporarily understood, is a result of the seventeenth and nineteenth centuries' synthesis of knowledge and knowledge production, as was discussed in Chapter 2, section 2.3. The historical progress of societies mentioned in the objective is, most possibly, directly associated with the development of 'Western' and European societies in the eighteenth, nineteenth and twentieth centuries. Although a critical analysis of progress due to scientific development is proposed, it does not seem to involve a de-construction of the concept of historical progress. Moreover, no specification of context is made with regard to contemporary societies. It is difficult to envisage discussions on historical progress in non-'western' countries or on the role of scientific and technological development in developing countries. There seems to be a universal understanding of progress embedded in the objective.

Finally, this objective is comprehensive for Key Stage 3 (DGEBS, 1991a). This means that not only it is part of the physics and chemistry and natural sciences curricula. It is also part of the curriculum of history, geography, mathematics, technological education, and personal and social formation. Thus, an image of progress as defined by the ideology of modern science may be transmitted in lessons of various subjects of Key Stage 3.

The examples above point to an implicit presentation of the concept of progress not only in relation to modern science but also within a universal framework. The following example, from the physics and chemistry curriculum, is more explicit than the others: it considers *humankind's global future*:

> The contemporary world is constantly being modified by the discovery of new knowledge. Great scientific and technological innovation made our societies' progress possible, which depends, more than ever, on the efficacy put on the use of such knowledge, on the capacity for the introduction of innovation in all fields, and, more importantly, on the ability of practising critical reflection capable of promoting right and informed decisions considering humankind's global future.[67] (DEB, 1995, p.7)

Modern science is presented at the core of the social and economic development of humankind. The 'global future' is considered in its dependency. This objective is an example of the presence of the ideology of modern science in the curricula. Sustainable development is presented in the dependency of scientific and technological development. No consideration of the 'Western' nature of the concepts of progress and sustainable development (as discussed in Chapter 2) is undertaken.

Similarly, in the chemistry component one finds the following objective:

> To illustrate Chemistry's importance as a response to Man's and Society's demands.[68] (DEB, 1995, p.50)

Again, one can ask, to which 'societies' and to whose 'man' is this objective referring? Scientific development is presented as inevitable and as a demand for progress, to be applied in global terms. Specific characteristics of groups of people and countries are not at all considered. Ways of life oriented by scientific and technological development may be understood to be superior and to be extended world-wide. Along with that goes a societal model of the societies in which modern science has been developed: 'Western' societies.

Natural sciences curriculum

> To understand that the regulation of human births must involve respect for Life and the sense of citizenship responsibility.
>
> To recognise the implications of new technology within the sphere of Man's reproduction.[69] (DGEBS, 1991c, p.9)

In the above objectives, one can find references to technological evolution which affects concepts of life and involves citizenship attitudes. Yet, as there are no cultural references to the nature of the concepts of life and progress involved, one may consider that they have a 'Western' nature. 'Western' understandings of dealing with human reproduction may then be transmitted as the right means to deal with it.

Through the various Key Stages one finds references to the role of modern science for societal progress in the science curriculum. Scientific development is often perceived as a positive feature of societies, however, these societies are not contextualised. No references were found regarding the discussion of progress in particular societies and how scientific and technological developments may affect each society in particular. References are made to the notion of historical progress but without consideration of a de-constructing of it. Modern science and 'Western' societies as we know them are not timeless, although that seems to be the implication when historical progress is considered.

Words such as *global* and *humankind* are used in some of the objectives which were discussed. Scientific and technological development appears in the latter within a global framework. Yet, as the discussions in Chapter 2, section 2.3 pointed out, the evolution of modern science and technology has produced different effects in different parts of the world. Moreover, there are various societal models in the world, which not only vary in social and economic terms but also, in cultural ones. Different societies understand modern science and technology differently. Some societies, many of them in Africa, hardly have contact with scientific and technological products. The science curriculum seems to disregard these aspects. It will be mainly dependent on the teacher to discuss them. The curriculum seems to support an image of social and economic development based on scientific knowledge and technology. Such an image is part of the ideology of modern science. The latter is embedded in the examples that were discussed and consequently, in the orienting conceptual framework of the science curriculum.

Curriculum content characteristics

Key Stage 1

Study of the surrounding environment curriculum

This curriculum contains an area dedicated to interrelations between nature and society: *Discovering the interrelations between nature and society.* This section involves discussions on agriculture, fishing, industry and other social activities. It also involves the scientific and technological presence within them. Although discussing issues such as the quality of the air and water (Ministério da Educação, 1990, p.95), no discussion or de-construction of the ideological concept of progress and its associated economic and social constructions of difference is referred to and advised.

Key Stage 3
Physics and chemistry curriculum

Within the chemistry component, an image of chemistry as the means to progress can be found at the level of contents, as follows:

> Chemistry as the answer to questions about the material world.
> The questions answered by chemistry.
> Chemistry and man and society's demands.[70] (DEB, 1995, p.50)

Year 3 of this Key Stage involves the optional content area *Chemistry and its impact in society: a first retrospective.* Within this are the following themes, which are considered for group work:

1. Chemistry and industry
2. Chemistry and the environment
3. Chemistry and agriculture
4. Chemistry and health
5. Chemistry and consumer defence[71] (DEB, 1995, p.18)

These themes have hardly any references to what should be taught or discussed in the lessons attributed to them (DEB, 1995). It is up to the teacher to decide about contents and their organisation. Consequently, no specific reference is made in terms of de-constructing notions of social and economic progress in relation to modern science. The notion of *societal impact* is not defined. There are many possible forms of impact depending on the nature of each society, or on the characteristics of each group within the society, to consider just two examples. The impact of chemistry in society may be good or bad for the whole society, for some groups, for the environment, again just to consider a few examples. Nevertheless, no references on any of these issues can be found in the content area.

Physics component

Embodied within the defined thematic areas of the physics component is the importance of making modern science closer to citizens, and of discussing eventual negative outcomes of scientific and technological development in general terms. However, these discussions are limited in scope and they do not necessarily propose a de-construction of the concept of social and economic progress associated with modern science.

For example, in Thematic area E – 'Energy production and consumption', energy crises are considered in order to present the fundamental role of modern science in the production of energy. They are also considered as a means to understand the relativity of the notion of crisis in terms of the physical concept of energy conservation (DEB, 1995). There are no references in terms of what is compulsory for this thematic area regarding for example, the de-construction of the relation between modern science and locus of power in the world-wide distribution of energy, and on the consequences of that for economic and political divisions between countries and groups. The only concrete mention of energy issues within such a framework is part of the suggested activities, and it concerns the development of research regarding causes and consequences of energy crises (DEB, 1995, p.64). No specific references are made at the level of contents or specific objectives. It is up to the teacher to decide whether the concept of progress, with its values and limitations, associated with scientific and technological development in terms of energy will be discussed or not.

Another example is taken from Thematic Area F – 'Transport and security'. Within this thematic area, all discussions regarding oil consumption and its effects on society and environment are not compulsory. No mention is made of discussions on the political and ideological notion of progress and its relation to modern science. For example, no references are made to how scientific and technological development in association with politics may affect world-wide distribution of oil with associated consequences for different cultural groups (DEB, 1995).

As with the results from the analyses of the curriculum conceptual framework, here also, there seems to be no reference made to a de-construction of social and economic notions of progress in relation to modern science. A concern regarding an analysis of modern science in terms of its impact in society is presented. However, the latter is broadly and ambiguously defined. Notions of progress as defined within the ideology of modern science seem to be present in the science curriculum.

Answering Elements to the Research Questions

From the analyses above, some answering elements for the research questions posed in Chapter 5, Section 5.3, will be put forward.

Research Question 1

How does the ideology of modern science, if present, contribute to a cultural evaluation of different metanarratives on the natural world and, consequently, of different cultures, through the science curriculum?

The analyses point out the presence of the ideology of modern science in the science curriculum. This was particularly the case for the notion of *modern science as the metanarrative on the natural world.* While presenting scientific answers as the answers, while omitting references to other metanarratives, and while taking for granted the nature of scientific knowledge, an image of modern science as the metanarrative on the natural world may be most surely transmitted. This metanarrative is mainly presented as the explanation of fundamental human questions from the origin of the Universe to the nature of matter and the concept of health. Although scientific knowledge is presented under the shape of concepts, laws, theories, and models, the latter tend to be presented as *the* explanations. Consequently, even if in time these concepts, theories, laws, and models may change, the idea of the nature of modern science as *the* definitive explanation is most surely maintained.

Modern science as a metanarrative on the natural world is a cultural element. Under these circumstances, cultural superiority is thus implicitly awarded to the owners of modern science. Consequently, one can argue that within the subjects of biology, physics, and chemistry, implicit cultural evaluations of different metanarratives on the natural world are very possibly being transmitted. These evaluations favour 'Western' culture.

Research Question 2

How does the ideology of modern science, if present, contribute to a cultural evaluation of different means of reasoning, and consequently, of different cultures, through the science curriculum?

The ideology of modern science regarding understandings *of scientific means of reasoning as the means of reasoning* can be found in the science curriculum as highlighted by the analyses.

Through the various Key Stages and the various science subjects considered, emphasis is placed on the development of skills in association with the deductive method. In fact, most of the objectives are subject comprehensive for each Key Stage. An objective regarding the development of respect for the deductive method is even defined. All students, regardless of their cultural background, are required to learn how to think scientifically, which appears to be presented, implicitly, as *the* reasoning.

Several possible associated consequences can occur. One of these is the implicit attribution of a superior cultural value to means of reasoning associated with modern science. Since modern science is perceived as a cultural element, superior value is attributed to the culture to which it belongs. That is, 'Western' culture can be implicitly considered superior to other cultures. Consequently, the Portuguese science curriculum regarding physics, chemistry, and biology can contribute to the stressing of the ideological notion of the cultural superiority of 'Western' culture.

The second consequence is of a practical nature. Within a culturally diverse context, such an emphasis on the development of particular forms of reasoning may imply a homogenising of the means of reasoning among the school population. That is, the development of other means of reasoning characteristic of other cultures may be suspended by persisting with the development of scientific ones. Consequently, an element of 'Western' culture is transmitted within a framework of cultural superiority, and may be practically affecting the transmission of cultural elements from other cultures, regarding means of reasoning and understanding. As such, it is possible to argue that the science curriculum may not only contribute to cultural evaluation. It may also participate in processes of assimilation regarding means of reasoning.

Research Question 3

How does the ideology of modern science, if present, contribute to the definition of 'Western' means of understanding cultural difference as *the* means of understanding such a difference, via the science curriculum?

Quite often, scientific means of reasoning appear in the science curriculum as *the* means of reasoning, as considered by the elements put forward in the previous research question. An immediate implication regarding understandings of cultural difference is that if those understandings are obtained via scientific means of reasoning, then they are perceived as the *truth*. Moreover, as they are a scientific result, they are *the* explanation, as discussions regarding research question 1 put forward. One can then argue that the superiority attributed to the 'West' via science education, regarding scientific means of reasoning and understandings of knowledge, can also imply the attribution of superior value to 'Western' understandings of cultural difference even if these are not explicit in the curriculum.

Research Question 4

How does the ideology of modern science, if present, contribute to the development of a comprehension of cultural evolution that privileges the 'West', through the science curriculum?

As considered in the previous research questions, various elements of the ideology of modern science can be seen in the Portuguese science curriculum.

In the examples discussed in the analyses one tends to find an implicit association between progress, due to scientific development, and societal cultural evolution. Even if issues are raised concerning eventual negative outcomes of scientific applications, the positive nature of scientific development as a means for society to evolve is hardly threatened. Moreover, similar evolution appears to be desirable for other cultural groups within a framework of a *humankind global future*. In other words, the ideological notion of progress embodied in the Portuguese science curriculum can be seen as involving the following ideas: a) the cultural superiority of the 'West' – modern science is part of 'Western' culture and it is the element for progress; b) similar progress is desirable for all – cultural homogenising through scientific development is considered within a framework of cultural imperialism.

Progress, within a 'Western' framework defined by scientific and technological evolution, is perceived as global. This progress has social and economic outcomes, which are not often de-constructed in the Portuguese science curriculum. The latter tends to consider progress within a positive framework even if several of its aspects deserve to be critically analysed. This is in agreement with the curriculum embodying the promotion of scientific literacy. On the one hand, economic and social globalisation is considered desirable within the ideological concept of progress as defined in association with modern science. On the other hand, hardly any de-construction of inequality as a consequence is considered. The proposed discussions of the *impact* of scientific and technological development in societies are not quite clearly defined. Topics on such an issue are mostly dependent on the teachers' choice and attitudes towards it. The analysis allows one to argue that the Portuguese science curriculum is possibly implicitly contributing to the promotion not only of a cultural superiority of the 'West' via the ideological notion of progress as defined by the ideology of modern science, but also of social and economic constructions of cultural difference, as issues of inequality in association with culture are generally omitted.

Science education in Portugal developed along with political change. The latter involved new understandings of education and modern science in and for Portuguese society. The compulsory science education curriculum is a result of these changes. It is pervaded with problem-solving and constructivist approaches. It pays particular attention to issues of scientific literacy. However, as the curricular analysis pointed out, the curriculum is also embodied in the ideology of modern science. This embodiment may have important outcomes in terms of understandings of cultural difference, as the promotion of 'Western' cultural superiority was persistently implicitly found in the examples discussed in this section.

6.5 Conclusion

Portugal has undergone a great deal of change during the last decades of the twentieth century. It moved from a closed, conservative, economically under-developed country to a democratic member of the European Union, in which capitalism rapidly introduced a whole new set of values. Internally and externally, the country was perceived as the closest example to the nation-state model. Contemporary Portugal, however, is as diverse as many of its EU partners.

Understandings of cultural difference in the country were traditionally associated with a sense of pride both in the empire and in the ability to maintain a different political regime to that of most other countries in Western Europe. This was for a long time the state's ideology. Contemporary Portuguese understandings of cultural difference are mainly rooted in understandings of Black otherness as a heritage of nationalism based on colonialism and imperialism. European otherness was diluted with the advent of joining the EU. Skin colour racism is very significant, along with new developments of institutional and cultural racism. Moreover, Portuguese society has not yet come to terms with its culturally diverse nature. A consequence of that can be seen in the ways by which Portuguese education deals with cultural diversity.

Portuguese education also suffered rapid and significant transformations during the last decades of the twentieth century. For a long time, a policy of promoting illiteracy oriented the educational policy in the country. The major challenge for the Portuguese State of the 1980s was to democratise education. Mass education was introduced and basic education was made compulsory. A great deal of reform was inspired by external models since the country was rapidly changing under the supervision and orientation of the EU. Intercultural education was introduced with educational reform in this framework. Fair importance was given to it. Such an importance diminished in time while, paradoxically, the culturally diverse nature of the country increased. Portuguese education is mainly designed for the white, middle class Portuguese, disregarding the fact that Portuguese society is socially and culturally diverse.

With educational reform a lot of attention was paid to the development of science education. This was in agreement with new state understandings of modern science. During most of the twentieth century, Portuguese politicians sustained the idea of Portugal as a rural country. Portuguese fascism was not progressive and industrialisation was seen as a dangerous means of working class empowerment. After 1975, a policy for scientific and technological development was demanded from the state. This became a reality in the 1990s with significant implications for science education.

Two main aspects were perceived to be very important for the development of modern science in Portugal: 1) the creation and maintenance of a good scientific community; and 2) the development of positive images of modern science among the country's population. These two aspects oriented the development of science education under the aims of: 1) science education for scientific and technological development of the country; and 2) scientific literacy. Both aims were a great deal directly related to the ideology of modern science. In fact, as the curriculum study has pointed out, one can find the ideology of modern science in Portuguese science education regarding understandings of the latter as the metanarrative on the natural world; understandings of the scientific methodology as the means of reasoning; and a comprehension of social and economic progress as directly related to modern science.

These characteristics of Portuguese science education may have important consequences for the understandings of cultural difference in the country. They may promote a 'Western' empowerment via the attribution of superior value to 'Western' culture, to 'Western' means of reasoning, and to 'Western' understandings of the natural (and social) world.

Chapter 7

Science Education, Cultural Diversity and Modern Science and Its Ideology in England

7.1 Introduction

This chapter follows the same orientation of Chapter 6. It contextualises and develops the discussions of Chapters 2, 3 and 4 applied to the case of England. The chapter involves three sections and a concluding one. The first section considers general characteristics of contemporary England focusing on issues of cultural diversity and modern science and its ideology. Analytical discussions on Britishness and Englishness are put forward along with social change which motivated political movements for cultural recognition. Issues of racism in its various forms – skin-colour, cultural and institutional – are also discussed. State cohesion and a revival of Britishness are analysed considering the specific case of scientific development. Finally, understandings of modern science in the country are outlined.

Social changes tend to contribute to educational change. The second section of the chapter analyses contemporary English education, giving particular attention to the culturally diverse nature of English society. The centralisation of education and economic demands from education will be discussed. So will the government education ideology, 'skills and employability for all'.

An analysis of contemporary English science education constitutes the third section of the chapter. This analysis focuses on issues of understandings of cultural difference and the ideology of modern science in science education. A discussion on understandings, aims and general characteristics of science education initiates the section. A curricular analysis of physics, biology and chemistry defines its core according to the orienting elements put forward in Chapter 5. The results of the analysis are presented in the form of elements answering to the orienting research questions of this study.

7.2 Culturally Diverse England and Modern Science

After the revival of English nationalism supported by the Conservative governments of Margaret Thatcher and John Major, a clearer state political acknowledging of the culturally diverse nature of English society occurred under the New Labour governments as Gillborn (1999) stresses. This might be seen as a reflection of the increasing political strength of minority groups and the recognition that they comprise 6.5% of the British population (Cabinet Office, 2000), involving an increasing number of voters. However, understanding and accepting England as a culturally diverse society has been a complex process, rooted in old and new constructions of difference and otherness.

On Britishness

Understandings of English constructions of difference and otherness need to be seen in relation to British ones. They cannot be disassociated from the formation of a British identity. English national identity is only one of a group of national identities sharing a common state, defined as the United Kingdom. Originally such identity group was autochthonously based. With increasing movements of population its nature became diversified (Figueroa, 1999, Grant, 1997).

Regardless of each individual's national identity, all of those inhabiting Great Britain share a citizenship identity associated, and quite often defined, by the notion of Britishness. Linda Colley (1992) argues that the construction of Britishness, and thus difference in relation to it, goes back to the early nineteenth century. However, it tends to be influencing processes of identification until today. According to her, rational patriotism defined affiliation to a state by opposition to others in terms of religion; in this case, the Catholic French (Colley, 1992).

> Patriotism in the sense of identification with Britain served (...) as a bandwagon on which different groups and interests leaped so as to steer it in a direction that

> would benefit them. Being a patriot was a way of claiming the right to participate in British political life, and ultimately a means of demanding a much broader access to citizenship. (Colley, 1992, p.5)

This access allowed direct membership to the Empire. The establishment of Britishness was associated with the idea of the Empire, too. The latter was also a unifying means for the various groups constituting the UK, as Colley (1992) points out. In fact, for UK nations under English domination, it constituted a means for national self-fulfilment, in terms of pride and cultural superiority over external others. Again, according to Colley (1992), contemporary re-emergence of Welsh, Scottish and English nationalism can also be seen as a response to the end of the British Empire. This is particularly the case in terms of Britain's internal cohesion and of its societal understanding of the country's position in the world ranking of economic and political power.

Britishness was an umbrella that hid internal processes of difference and otherness. The various British groups were 'others' of each other, with the English one dominating the Welsh, Scottish and Irish. Internal otherness has always been a characteristic of the UK, and Welsh, Scots and Irish have traditionally been the internal English others (Grant, 1997).

On Englishness

The end of the Empire intensified economic and political migration to the UK, and thus, to England. This brought external others to a society that had originally defined them. In fact, migration to England was going on long before the end of the Empire, even if on a smaller scale. However, relations of political imperialistic domination were operating, which contributed to deny identity recognition to the incoming migrants. Individuals from the colonies were generally classified as black others, culturally inferior to the English and to the British.

The movements of population towards England after de-colonisation were taken mainly as an alien invasion once statutory colonial attachment and domination between and over groups was no longer in operation. Englishness, English culture and values were seen to be under threat by the presence of *too many others* among *us*. Skin colour racism became a more visible characteristic of English society and racist events defined a great deal of the late 1970s and 80s. As Gundara (2000a) considers, political stress on Englishness defined by Conservative governments supported group divisions and minimised the role of the Commission for Racial Equality and the importance of the 1976 Race Relations Act.

The 1976 Race Relations Act was the result of a period of conflict between dominant and non-dominant groups. Ignorance followed by assimilation were the political ways initially chosen to deal with cultural diversity in England (Gillborn, 1999). Nonetheless, many groups could not assimilate, living conditions were bad for migrants and they were the persistent object of racist attacks (Gillborn, 1999). As a response to the demands of non-dominant groups and to potential social instability, Thatcher's governments moved towards integrationist policies and colour-blind discourses parallel to others on Englishness (Gillborn, 1999).

Political Recognition of Cultural Difference and Cultural, Institutional and Skin-Colour Racism

Difference had been constructed in the UK, and thus in England, mostly under the following forms:

a) internal, directly related to the various autochthonous groups inhabiting the United Kingdom, with otherness defined in relation to each other;
b) external, directly related to migrant others.

The first form defined political domination and to a certain extent, cultural imposition regarding dominator over dominated; that is, from the English over the Welsh, Irish, and Scots. The second form involved skin colour differentiation along with social and economic discrimination. In both cases, politics of recognition produced political change and new understandings of cultural diversity.

The last decades of the twentieth century were the scenario of basic transformation in the internal structure of the UK. With Scottish devolution, Scottish and Welsh national identities became politically recognised by the UK state (Gundara, 2000a). This implied political recognition of cultural difference in internal terms. Nonetheless, such recognition continues to be a basic demand of non-dominant groups. The 1980s were strongly characterised by racist events and by anti-racist struggles. However, as Gillborn (1999) and Gundara (2000a) have noted, with the rise of the 'New Right', this decade and the one that followed were to be characterised by the introduction of cultural racism.

According to Gillborn (1999), the 'New Right' discourse, making use of the political correctness movement, hid traditional notions of 'race' in the word 'culture'. Dominant and non-dominant groups were then defined in cultural terms. The revival of Englishness was presented as the natural reaction to England's cultural invasion. Otherness was defined in terms of cultural difference, and racism was hidden under the belief in the need for English cultural defence (Gillborn, 1999).

Studies of the last decades have shown how cultural and institutional racism have been in operation in England. Many of these studies focused on the educational system and have highlighted the presence of colour, cultural and institutional racism in English education (see for example Gillborn, 1990, Gillborn and Youdell, 2000, Owen et al, 2000). Other studies have also shown the social and economic characteristics of non-dominant groups in this country. According to the Social Exclusion Unit work,

> In comparison to their representation in the population, people from ethnic minority communities are more likely than others to live in deprived areas; to be poor; to be unemployed, compared with white people with similar qualifications; to suffer from ill-health and to live in over-crowded and unpopular housing. They also experience widespread racial harassment and racist crime and are over-represented throughout the criminal justice system, from stop and search to prison. (Cabinet Office, 2000)

Moreover, according to this Unit, it is estimated that 93% of racial attacks occurring in England and Wales are perpetrated by white people (Cabinet Office, 2000). Although political recognition of cultural diversity has been more expressed after the New Labour governments, and attention was given to the social exclusion of ethnic minorities by the Social Exclusion Unit, otherness, defined in terms of skin colour and culture seems to be a persistent characteristic of English society. Again, according to David Gillborn (1999), while discussing English education, although changes have occurred at the political level, these still do not directly tackle issues of 'race' and racism.

Britishness Revived

Constructions of cultural difference in England tend not only to persist in defining others in external ways, now determined in terms of culture, but they also tend to imply their social and economic discrimination. Moreover, they have implied the maintenance of various forms of racism (Gillborn, 1999). Cultural diversity is not a temporary phenomenon. Many individuals from migrants' second and third generations see Britain as their country of origin. This implies the establishment of individual and collective identity balances in terms of culture and citizenship. This last category defines a common attachment to the UK state for English and non-English individuals. In fact, it can be considered the means of identification that justifies in a neutral manner individual and collective senses of belonging (Gundara, 2000b). Needs for social cohesion and senses of inclusion have produced the revival of Britishness.

It was argued at the beginning of this section that the construction of a British identity could be seen as a need for state cohesion in the UK, and that it implied the definition of external common others such as the Catholic French, as Colley, (1992) pointed out. Therefore, citizenship was at stake as the unifying variable. Similarly, contemporary Britishness can be seen again as the result of political attachment to the UK state of all citizens living within its borders; that is, of individuals from dominant and non-dominant groups. As Gundara (2000a) considers, although cultural difference and otherness are persistently being defined within England, UK individuals, English or not, from dominant or non-dominant groups share common external others. This supra-external definition of otherness can be seen once more as a means of state cohesion. It is presented in political, economic, social and cultural terms. It is expressed, for example, in sports competitions and in the political understandings of the UK in relation to the European Union (Gundara, 2000a).

Contemporary means of identification in England are complex in nature and form. As Coulby and Jones (1995) note, the stability of the state is defined by a balance between its needs and the demands of the various groups, which although differentiating themselves in relation to one another, are unified under the category Britishness. Not only is Britishness thus fundamental for each individual but it is also basic for state cohesion. Individually, Britishness often culturally defines citizenship. For the state, it generally implies political reassurance. Within this framework, Britishness has to be constructed in ways that involve supra-cultural possibilities of affiliation. The example of sports has already been mentioned. Another example is that of scientific and technological development.

The Case of Modern Science

Scientific and technological development is many times taken as a source of state pride and a means of state definition in the world ranking of political and economic power. In the foreword of the Science White Paper 'Excellence and Opportunity', one reads:

> The UK has 1% of the world's population but we fund 4.5% of the world's science and produce 8% of the world's scientific papers. In the 21st century, we must remain a world leader in science. (...) To be a successful nation we must make sure our science base is strong and excellent, that we have the facility to quickly transform the fruits of scientific research and invention into products and services that people need to improve their well-being and quality of life. (DTI, 2000a)

The quotation above presents UK's scientific and technological development as a unifying means and source of national pride: 'we must remain a world leader in science (...); to be a successful nation (...)'. At the same time, it embodies the state understanding of modern science and of the latter's relation with society: the results of scientific research are to improve people's well-being and quality of life. This understanding of modern science is directly related to notions of social progress, contemporarily embodied in the idea of sustainable development.

English Understandings of Modern Science

The concept of sustainable development is clearly present in English political discourse regarding modern science (see for example DTI, 2000a, 2000b). This is particularly the case in terms of the relation between modern science and economic outgrowth.

> For Britain to prosper in the 21st century and to be able to play a leading role in the creation of the new global industries, we must have a first class process for pursuing scientific advance and using it successfully. We must have the ability to generate, harness and exploit the creative power of modern science. (DTI, 2000a)

This relation between modern science and economy is not a recent one in English politics. As Green (1995, 1997) argues, the development of technical education in the nineteenth century is seen as the result of fears of economic under-development in relation to French and Prussian industrial advances. Again, and according to Aldrich et al (2000), in the late 1950s, emphasis on scientific development for economic improvement and supporting democracy was also put forward. By then, concern with Britain's economic decline was a constant of political discourse. Scientific and technological development was taken as a very important means for combating such a decline. The famous C. P. Snow paper on 'the two cultures' was of special importance in those days. As noted by Aldrich et al (2000)

> From the late 1950s the 'national efficiency reformers' of the period held that reform of the machinery of government and an improved educational system could arrest or reverse relative national decline. Solutions to the problem of decline were often based on an association of science with democracy, as against classical learning and privilege. (Aldrich et al, 2000, p.126)

Modern science although presented in economic terms was also at this time, used as a political weapon. It defined a political group, which was opposed to another, represented by traditional academics and aristocrats. Moreover, modern science was seen as a basic objective tool to be used in governance. Again, as Aldrich et al (2000) suggest

> Snow's arguments and hostility towards 'literary intellectuals' were clearly compatible with Wilson's campaign to promote Labour as the party of the scientific revolution, in contrast to the supposedly effete, aristocratic Conservatism of Macmillan. (...) Science, democracy and modernity were closely linked in the writings of Snow, Wilson and others of the time. The basic theme of modernisation encompassed both the wider culture in society at large and the more specific culture of government and administration. Snow himself, was the personification of the scientist/administrator/moderniser. (p.127)

Later, governmental change created the Department for Education and Science, directly stressing the importance of modern science and of producing a strong scientific community through education. Then, as now, one finds a particular understanding of modern science behind political developments. Modern science is understood as the provider of objective answers and solutions for economic and social progress/sustainable development. Stephen Byers considers that, 'our lives would be unimaginable without science. When it is guided and regulated in the right way, science brings prosperity, improves the quality of life and extends life choices for all' (DTI, 2000a). Moreover, scientific advice is indispensable for good policy development (DTI, 2000a).

Issues of regulation are a political concern regarding scientific development. They also contribute to the definition of the government's role in the latter. Contemporary English understandings of such a role are as follows:

> The Government's aim, therefore, is to invest in the science base, with measures to open up channels to allow scientific know-how to flow beneficially through to society, into business and jobs, and also into health care, public services and the environment. (DTI, 2000a)

> Government must play many roles. If the UK is to seize the opportunities presented by current rapid advances and breakthroughs in science, Government must be an investor, a facilitator and a regulator. The market alone will generate neither the basic investment in research, nor the networks to link universities and business, nor the public confidence to drive innovation forward. (DTI, 2000b)

This implies an interaction between the government, education and industry in which the market plays a basic role, determining the nature of innovation. An example of this is given by the amount of money spent by the UK government in different areas of research and by the choice of such areas. At the moment those are: Genomics, E-science and Basic Technology (OST, 2001). Nonetheless, the possibilities of a successful interaction are perceived to be in the hands of the public. Trust in modern science is felt to be permanently desirable. Recent events have implied a great deal of social distrust in scientific knowledge, especially concerning its ability to provide answers. England has been at the heart of the situation in crises such as that of foot and mouth disease. For the Government, the maintenance and improvement of the level of scientific and technological development implies a strategy for increasing public support for modern science.

> Science must be our servant and not our master. Public acceptance of science cannot be taken for granted. The challenge for scientists is to engage with people in debate about the benefits of what they do; Government must complement this by providing a strong and open framework of regulation, supported by scientific evidence and independent scientific advice. (DTI, 2000a)

Several measures were then considered; among them the definition of guidelines for scientific advice and policy-making (OST, 2000), stress on scientific literacy, and the definition of the academic year of 2001/2002 as the *Science Year* (DTI, 2000a). In fact, these initiatives can be seen as expressing the difficult balance between the state's need for support in terms of scientific and technological development, and the individual and collective recognition of the association between modern science and risk[1]. As Lash et al (1996) put it: 'as modern science has expanded its social authority and its social reach, its formalised and reductionist vocabularies have delegitimated and displaced many of the more situated understandings that people have of the world and their place in it'. (p.13)

Scientific developments such as those in genetics reinforce notions of risk, which can be directly related to each individual's innermost form of identification: his/her genetic matrix. In English society such concerns are explicit: for example, insurance companies have already initiated new processes of discrimination based on genetic records (Human Genetics Commission, 2000). As a means to respond to such a complex matter a document was drawn up for consultation by the Human Genetics Commission – *Whose Hands on Your Genes?* – for future policy development regarding genetic manipulation and engineering (Human Genetics Commission, 2000).

Developments in the field of genetics and genetic manipulation revived old memories of social Darwinism and eugenics, and of the relation between modern science and dominant and non-dominant groups. In fact, within state documentation on modern science the culturally diverse nature of English society is generally ignored. In practical terms, considering issues of cultural diversity, modern science and contemporary English society have a rather complex relation with possible ambiguous outcomes. One the one hand, modern science can operate as a unifier of British people, thus supporting the cohesion of the British state. On the other hand, and according to the discussion in Chapter 2, section 2.4, as modern science is also perceived as the provider of answers and the means for sustainable development, one can infer that it tends to be ideologically evolving as a state's supporter in opposition to cultural diversity. Understandings of modern science as the provider of answers and the source for sustainable development can support ideological, social and economic processes of differentiation that may have negative implications for non-dominant groups in English society and thus for state cohesion.

As England is part of the UK state, English society has always been culturally diverse. Internal otherness defined in relation to Scots, Welsh and Irish was however, parallel to external otherness directed towards many different groups such as the French or those associated with colonised peoples. The definition of Englishness seems to be related also to understandings of Britishness. The conflict results from the fact that the English constitute the dominant group in a state where many others demand cultural recognition. Britishness is many times considered as the common state identity; Englishness has been often the tentative and imposed cultural identity.

Politics of recognition have exposed racist and discriminating characteristics of the English society. Issues of skin-colour, institutional and cultural racism were made visible. The state responded ambivalently to the demands of non-dominant groups and to racism exposure.

The reinforcement of British identity has been dependent on many factors, one of these being scientific and technological development. The latter is often understood as a source of pride and as a state unifier. However, underlying this understanding one can find aspects of the ideology of modern science. Ownership of scientific knowledge implies progress/sustainable development. At the same time, it implies the ownership of Knowledge as modern science is seen as beyond ideology. Such a comprehension can have fundamental importance for understandings of cultural difference as it tends to support traditional nation and state models of organisation.

7.3 English State Education and Cultural Diversity

Compulsory education in England involves children aged from 5 to 16 years old. Around 90% of all students in England attend state schools, and they are exposed to a National Curriculum to be complied with by each school (DfEE, 2001). This was not always the case. English education has a long tradition of de-centralisation.

Contemporary Understandings of Education

The National Curriculum is divided into four Key Stages that are defined by the pupils' age, as follows:

Key Stage 1 – Pupils aged 5 to 7 years old
Key Stage 2 – Pupils aged 7 to 11 years old
Key Stage 3 – Pupils aged 11 to 14 years old
Key Stage 4 – Pupils aged 14 to 16 years old

Common to all Key Stages and all subjects are particular understandings of education in and for societies.

> Education influences and reflects the values of society, and the kind of society we want to be. (...) Foremost is a belief in education, at home and at school, as a route to spiritual, moral, social, cultural, physical and mental development, and the well being of the individual. Education is also a route to equality of opportunity for all, a healthy and just democracy, a productive economy, and sustainable development. Education should reflect the enduring values that contribute to these ends. These include valuing ourselves, our families and other relationships, the wider groups to which we belong, the diversity in our society and the environment in which we live. (DfEE and QCA, 1999b, p.10)

The quotation above, taken from the English National Curriculum, embodies the general orienting lines of contemporary discourse on English state education.

Clearly it involves the promotion of individual and social development, as well as that of sustainable development. Education is directly linked to politics and the economy, and presented within the traditional modern framework of education for individual development, social cohesion and economic evolution. However, as will be argued, educational development tends to be mainly centred on economic aims. The main idea behind such a development can be summarised by an association between equality of opportunity, educational achievement, and *employment for all.* The basic role of education is thus perceived as one of skills transmission so as to ensure a future job for every individual, consequently, giving him/her a place in society while contributing to general economic prosperity. According to David Blunkett,

> A first-class education system must cater for all and it must recognise what is valuable in the labour market. We know that individual returns from education are high and this reflects the needs of a large part of the modern economy. (Blunkett, 2001a).

The Roots of Contemporary Education – Centralising Education

English education during the second half of the twentieth century has largely been influenced by the belief in educational development for the economic improvement of a society perceived to be in economic decline, as Aldrich, et al (2000) note. However, it suffered profound changes under different political orientations, which reflections can still be found. This is particularly the case for the transformation brought about by the 1988 Education Act, which introduced the 'nationalising' and centralisation of control over state education (Aldrich, 1996, 1998, Aldrich et al, 2000, Davies and Evans, 2001, Jones and Kimberley, 1991). These elements are still with us today.

The Conservative governments of Margaret Thatcher and John Major introduced curriculum centralisation at the state schools level, while leaving unchanged the educational freedom of the private sector (Aldrich, 1996, 1998, Davies and Evans, 2001). Scholars like Aldrich (1996, 1998), Davies and Evans, (2001) argue that through standardisation of educational results, the principle of the comprehensive school was in practice abolished. According to Jones and Kimberley (1991), the following issues were behind the introduction of the National Curriculum:

1- The desire to shape the economy and to ensure that a work force is available to continue its expansion.
2- The desire for a clearly defined educational entitlement which is replicated in all parts of the country.
3- A set of beliefs about the inefficiency of state schools.
4- Specific attacks on progressive forms of pedagogy and curriculum development, particularly those perceived as threatening the status quo.
5- The intention to re-affirm traditional values and cultural traditions which have been felt to have weakened.
6- The intention to establish a set of boundaries for what is considered English. (Jones and Kimberley, 1991, pp.13-4)

These issues were very important in defining the nature and characteristics of the National Curriculum and, to a great extent, their influence can still be found in contemporary English education.

Education and Economy

The association between the economy and education was already an issue long before the Tory governments. An example of that is found in the debates on English understandings of education and modern science mainly developed after C. P. Snow's 1959 'Two Cultures' (Aldrich et al, 2000). Another reflection of the economic importance attributed to education was the creation of the Department for Education and Science (Aldrich et al, 2000). The National Curriculum constituted the definition and imposition of centralised aims and objectives in terms of education and economic development. The creation of the Department for Education and Employment (DfEE) expressed an understanding of education as a means to employability (Aldrich et al, 2000).

This is the case until today, even after the changes in the DfEE. Skills are perceived as a key element in information-technology societies. Skilled individuals are seen with higher employability potential and as basic elements for and in the market economy. The DfES (Department for Education and Skills) can be seen as reflecting an understanding of education still supported by aims of economic development, and defined by schools as transmitters of skills. As Estelle Morris put it in her first speech:

> That thirst for lifelong learning is vital to this nation's economic and social well being. Without a more highly-skilled workforce we risk relegation to the fringes of the great economies; but far more important to me, we will raise further generations who have not been given the tools or the aspirations to fulfil their potential - not just in work but in all arenas of life. And that would be a tragedy. (Morris, 2001)

Skills, Citizenship and 'Employability for All'

The idea of the skilled individual is thus also associated with that of the active citizen. Within such a framework, the various kinds of individual and social educational development are obtained mostly by the transmission of skills:

> Let me just say a word or two about what I feel about education, because I don't always get the chance to do it. It is my view that we are equipping young people for the world of work, to be able to earn their own living, in independence, in self-reliance. But their education is lighting a flame, which God willing, will carry all of us through our lives in the adventure of education. In the inquiring minds that we open up, so that people are looking for ways of absorbing learning, of being able to use information and education throughout their lives. The inspiration and potential that emerges from every individual youngster in the way in which they can access culture and their quality of life, the appreciation of our environment. (Blunkett, 2001b)

These citizens are regarded as the basic promoters of sustainable development. The latter constitutes a general governmental aim which, however, is dependent on education for the preparation of future generations characterised by active citizenship. Such a preparation is perceived to involve a common curriculum and an understanding of education as entitlement. Education as entitlement is also another issue, which was considered basic in the introduction of the National Curriculum, that is still supported today.

> The National Curriculum secures for all pupils, irrespective of social background, culture, race, gender, differences in ability and disabilities, an entitlement to a number of areas of learning and to develop knowledge, understanding, skills and attitudes necessary for their self-fulfilment and development as active and responsible citizens. (DfEE and QCA, 1999b, p.12)

This paragraph is found in the 1999 National Curriculum Handbook for Teachers. Such a notion of education has however, been the object of great criticism. The latter involves mainly two basic aspects: a) the imposition of a state chosen set of knowledge and skills; and b) the false idea of entitlement as state educational provision remained different from that of the private sector (Aldrich, 1996, 1998). In other words, all children are entitled to education; yet, only very few have a choice in terms of educational provision. Those who have such a choice are the ones with greater economic power. State defined knowledge and skills are imposed on the majority of the children including those with hardly any economic and political power. It can be argued that such a kind of educational provision perpetuates the socio-economic status quo as it does not consider all children in the same way. (For further discussion of this issue, see Aldrich, 1996, 1998, Jones and Kimberley, 1991).

The 1980s Government concern with the inefficiency of English schools had as a main result the development of educational standardisation supported by a public exposure of school exam results. Pressure was directly put on teachers and headteachers. The comprehensive school lost a great deal of its defining character and parental choice became a very important variable within state financed education. This was in agreement with the ideological orientation of the neo-liberal government that defined the 1988 Act (Aldrich, 1996, 1998, Aldrich et al, 2000, Davies and Evans, 2001).

Nonetheless, the idea of developing better schools was maintained by the New Labour governments. The 2001 Labour Party Manifesto considered school improvement a basic issue to be dealt with in education. It presented ten steps for better schools:

1. More money for education
2. 10,000 more teachers
3. More support for teachers in the classroom
4. Nursery places for every three-year old
5. Even higher standards in primary schools
6. Children to learn more music and sport
7. Every secondary school to develop a centre of excellence
8. Better IT and equipment for all schools
9. Stronger work-based options and apprenticeships
10. More students going to university (Labour Party, 2001)

These ten steps were the continuing of a policy of raising standards, particularly emphasising the promotion of literacy and numeracy. This policy follows the understanding of educational standardising defined by the 1997 White Paper – Excellence in Schools. In this document, six orienting principles were put forward. Four of these relate to school performance:

1. The focus will be on standards in schools, not the structure of the school system.
2. We will intervene in under-performing schools and celebrate the successful.
3. There will be zero tolerance for under-performance.

4. The Government will work in partnership with all those committed to raising standards. (Secretary of State for Education and Employment, 1997)

This policy is mainly concerned with the interaction between market needs and education. According to David Blunkett,

> One of the many reasons why all parts of the education system are vital to our economic health is that people who lack basic literacy and numeracy are harder to train and less likely to be trained. Thus a vital part of our policies for training the adult workforce is ensuring that people reach it with a good grounding in basic skills. This is a very clear illustration of how sensible education and training policies are essential complements to an employment policy that places emphasis on fairness through giving everyone the skills they need for employability. (Blunkett, 2001a)

Education and Cultural Diversity

Another issue behind the introduction of the National Curriculum according to Jones and Kimberley (1991), as presented above, was the concern with pedagogical practice which could affect society's status quo. This was considered particularly the case in big cities, and more precisely in London, with the educational projects and developments of the ILEA. A great deal of the latter was seen as a means of politically empowering disadvantaged groups (Jones and Kimberley, 1991). This empowerment was taken as a threat to traditional values and to English 'culture'. In fact the three last issues pointed out by Jones and Kimberley (1991)[2] are directly interrelated.

The 1970s and 1980s were characterised by a political struggle for minorities' recognition. As to the general policy directed to minorities, educational policy was characterised by different approaches. These have been extensively discussed[3] and they can be summarised by three main political attitudes: assimilation, integration and cultural pluralism (Figueroa, 1999, Gillborn, 1999, Grant, 1997). Debates on the problematic consequences of assimilation and integration, along with social manifestations of intolerance and racism, led to the development of educational trends such as multicultural education and anti-racist education (Gillborn, 1999). This practice occurred mainly in inner city areas, a great deal of it happened in London supported by the ILEA (Craft and Tomlinson, 1995).

In the eyes of Mrs Thatcher's Government such educational practice involved politically empowering non-English groups, which was considered and presented as an invasion of alien cultures. A shift was being developed from a definition of racism in terms of skin colour to one in terms of culture as Gillborn (1995) argues. Although the 1980s was the decade of the Swann Report, in political practice it was characterised by the idea that the interests of the majority come first because this is our country (Gillborn, 1999). Consequently, the 1988 Education Act and the National Curriculum that it introduced were characterised by colour-blindness, along with an emphasis on *Englishness* (Aldrich, 1996, Gillborn, 1999).

Although academic and political debate on the education of minorities is still a characteristic of the political arena in the UK, only fairly recently have New Labour governments brought the education of ethnic and minority groups to the state agenda. However, according to David Gillborn (1999) this has been a discrete process that has failed to address issues on 'race' as it is still embodied in notions of colour-blindness. As he puts it,

> Despite superficial changes that acknowledge ethnic diversity and value 'equal opportunities', contemporary policy is no more able to deliver equitable and anti-racist outcomes than previous policy perspectives. The 'naïve multiculturalism' of Tony Blair's government remains wedded to uncritical and often deficit notions of failure that continue to blame black students for their situation and fail to identify the deeply racialised and racist nature of contemporary education. (Gillborn, 1999, p.135)

In fact, at the National Curriculum level there have been hardly any changes regarding cultural diversity. The National Curriculum is generally blind to society's diversity. Issues on cultural diversity are mostly delegated to the school curriculum. Emphasis is put on the role of the teacher. Intercultural education developments as well as anti-racist ones are necessarily of an additive nature, dependent upon teachers' understandings of diversity and on their own creativity.

> When planning, teachers should set high expectations and provide opportunities for all pupils to achieve, including boys and girls, pupils with special education needs, pupils with disabilities, pupils from all social and cultural backgrounds, pupils of different ethnic groups including travellers, refugees and asylum seekers, and those from diverse linguistic backgrounds. (...) Teachers should plan their approaches to teaching and learning so that all pupils can take part in lessons fully and effectively. (DfEE and QCA, 1999a, p.61)

Insistence on difference as a category external to the population of the English educational system tended to be on the basis of New Labour educational developments regarding ethnic minorities. These have been mostly focused on issues of achievement. The DfEE commissioned a report on ethnic minority participation and achievement in education and the labour market, which has been used to develop documentation on means of raising achievement. This report highlighted the variety of educational achievement among different ethnic minority groups (Owen et al, 2000). It also stressed the under-participation of these groups in higher qualified professions, even if they are projected to account for more than half of the growth in the working age population over the next ten years (Owen et al, 2000).

In order to help schools and educational professionals to improve the achievement of ethnic minority groups documentation was published and a web page on such an issue was developed (DfEE, 2000a). The document *Removing the Barriers – Raising Achievement Levels for Minority Ethnic Pupils* is an example of that. This document identifies four basic areas to be developed in order to raise the achievement of pupils from ethnic minorities. These are:

- high expectations
- culture and ethos
- parental involvement
- ethnic monitoring (DfEE, 2000a)

These areas involve specific points, which are mainly external to the curriculum. In terms of the latter, considerations are made to the definition of inclusive school curricula (DfEE, 2000a). The National Curriculum, which is the basis of the educational system, can then be seen as involving cultural diversity in universal terms. The particular issues of cultural diversity in English society are delegated to the school curriculum. That is, it is each school that has to decide on how to deal with cultural diversity depending on its own understanding of it.

As a support to school initiatives for raising the achievement of ethnic minority students, the government created the Ethnic Minority Achievement Grant (EMAG).

> The EMAG provides for a significant element of devolution of the funding to schools. This will ensure that schools have a significant role in the effective management of this work, including appointing additional staff and purchasing appropriate resources, in order to form a key part of whole school approaches to raising ethnic minority achievement. (DfEE, 1999)

The EMAG is an important step for educational development regarding ethnic minorities. However, as South (2001) indicates:

> The effect of devolving funds to schools, together with their responsibility for determining the use of their EMAG budget within the broad constraints set by the DfEE, has given the opportunity for provision to be brought fully within schools'

agendas: the question is whether this will lead to improved quality of provision for ethnic minority pupils. (South, 2001, p.10)

The EMAG sets the responsibility for the education of minorities mostly in the schools. More precisely, it is the achievement of minority students that is at stake and not necessarily the education of a culturally diverse society. The importance and value of educating all children for life in a plural society can thus be disregarded. One can argue that schools are confronted with the need to raise the standards of pupils from ethnic minority groups, while preparing them for life in the English society. The education of the dominant group for life in a culturally diverse society will quite surely be left behind.

English education underwent considerable change when the 1980s educational reforms introduced educational centralising and standardisation. As this occurred at the state-funded schooling level, it left educational freedom and choice for those with more power within the society. Underlying contemporary English education are above all aims of economic development. These have a long tradition in the country. In a contemporary form such aims are associated with the development of skills. The latter are considered very important for citizenship and employability in an information-technology society. Within this framework, education for all is associated with employability for all. Yet, *all* are a culturally diverse group. In a culturally diverse society, educational achievement cannot be measured simply by standard examinations. It has to involve a comprehension of how education is preparing *all* to live in such a culturally diverse environment.

Cultural diversity has been recognised in the English educational system in external terms, that is, regarding external others. Original policies of assimilation and integration evolved to others on pluralism, which however tend to not affect the curriculum. The creation of the EMAG is a good example of how issues in intercultural education tend to be taken within a remedial framework. Science education is a basic subject in the English educational system. It is directly related to state aims of economic development. This relationship is supported by the ideological notion of progress, defined regarding modern science. It is important then to discuss how issues of the ideology of modern science are considered in the English science education curricula. Such a discussion will be the object of the next section.

7.4 Understandings of Cultural Difference and the Ideology of Modern Science in Science Education

Understandings, Aims and General Characteristics of Science Education

Modern Science and Economic Development

Contemporary education in England is mainly oriented by aims of an economic nature. These appear under the shape of development of skills. Education and employability are perceived in direct association. Skills are considered the basis of employability in an information-technology society supported by lifelong learning. Consequently, education as a transmitter of skills is one of the fundamental characteristics of contemporary English educational discourse.

At the core of information-technology societies lies modern science. Technological development is perceived to determine states' economic characteristics. Scientific and technological development is thus a major state aim. This is clearly the case in England. As Stephen Byers put it in the foreword of the White Paper 'Excellence and Opportunity':

> Science has become an integral part of our economy and society.
> The successful economies of the future will be those which excel at generating and disseminating knowledge and exploiting it commercially. (DTI, 2000a)

In order to provide for such a development two fundamental conditions should be met: a) the existence a continuing strong science base (DTI, 2000a); and b) a positive public attitude towards scientific and technological development (DTI, 2000a). In terms of the British government's role, it implies 'investing in scientific excellence, increasing opportunities for innovation, and providing a basis for public trust in science' (DTI, 2000a). One way to do it is through science education.

Science Education Aims

> We need better science in schools, so that every child has the opportunity to make sense of the world around us and the way it is changing; and to give the best start to those who choose to work in science, engineering or technology. (DTI, 2000a)

The development of science education in England tends thus to be oriented by the transmission of skills and the promotion of scientific literacy so that scientific and technological development may continue with society's support. Within this framework, great emphasis is given to scientific methodology and to the role of modern science for sustainable development (DfEE and QCA, 1999b). However, modern science is presented as a means of progress, within a framework of active citizenship control.

> Our lives would be unimaginable without science. When it is guided and regulated in the right way, science brings prosperity, improves the quality of life and extends life choices for all. Much of everyday experience - even the jobs we do - is the product of scientific advances in the past. And just as important, science is helping to create the global markets and industries of the future. (DTI, 2000a)

Within this understanding of modern science and development,

> Education for sustainable development enables pupils to develop the knowledge, skills, understanding and values to participate in decisions about the way we do things, individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future. (DfEE and QCA, 1999b, p.23)

The skills associated with scientific methodology are perceived to provide objective means of reasoning so that decisions can be made. Scientifically literate individuals are thus understood as active citizens.

General Curriculum Characteristics

Such an understanding of science education has important reflections in curricular terms. For example, fundamental importance has been given to primary science education after its introduction by the 1988 Education Act (Davies and Evans, 2001, Ritchie, 1996). Another example is given by the introduction of the study area *Scientific Enquiry* in science education after the last National Curriculum revision. This study area is present in the whole of the science curriculum, and it is to be developed along with all the other study areas of the latter (DfEE and QCA, 1999a). This is in agreement with the government's comprehension of the importance of problem-solving and of the role of modern science in it.

> The key skill of problem-solving involves pupils developing the skills and strategies that will help them to solve the problems they face in learning and in life. Problem-solving includes the skills of identifying and understanding a problem, planning ways to solve a problem, monitoring progress in tackling a problem and reviewing solutions to problems. (DfEE and QCA, 1999b, p.21)

Under this orientation science education constitutes one of the three core subjects of the National Curriculum, along with English and mathematics. This is the case for all Key Stages, from one to four. In Key Stage 4, students can choose from two programmes of study: single or double science. The difference between them lies in the number of hours allocated to science teaching and learning. Single Science is designed for students who will pursue careers unrelated to modern science. The Government's emphasis on science education is such that it

> firmly believes that double science or the three separate sciences[4] should be taken by the great majority of pupils. Single science is intended for a minority of pupils

who have a good reason to spend more time on other subjects. (DfEE and QCA, 1999a, p.6)

Compulsory general science education is not subject-based. Several natural sciences are represented in the subject science education. This is case for biology, physics, and chemistry, which have a strong representation in all Key Stages. Within each Key Stage four areas of study are considered, involving *Knowledge, Skills and Understanding* (DfEE and QCA, 1999a, p.6). These are:

1. Scientific enquiry
2. Life processes and living things
3. Materials and their properties
4. Physical processes (DfEE and QCA, 1999a, p.6)

'Scientific enquiry' is directly related to the development of skills and means of reasoning associated with scientific methodology, as already considered. 'Life processes and living things' fundamentally involves elements of biology. 'Materials and their properties' mainly considers elements of physics and chemistry. Finally, 'Physical processes' involves elements of physics. Attainment targets were defined for each of the areas of study.

The proposed total number of hours for science teaching and learning according to the QCA Scheme of Work for Science Key Stages 1 and 2 is as follows (DfEE and QCA, 2000):

Key Stage	Year	Hours for science learning
1	1	49
1	2	51
2	3	65
2	4	66
2	5	67
2	6	64

Specific curricular characteristics are left for definition in the school curriculum.

Science education constitutes a fundamental subject of the English educational system. A main reason for that relates to understandings of the importance of scientific and technological development for economic evolution. So science education is oriented by aims of economic development and the promotion of scientific literacy in order to promote the existence of a good scientific community and positive attitudes towards modern science. One can argue that underlying these aims is the ideology of modern science. The following curricular study attempts to contribute to a better understanding of the presence of the ideology of modern science in English compulsory science curricula with reference to issues of cultural difference.

Curriculum Analysis

Data Presentation and Analytical Discussion

As was the case in Section 6.4, the curricular analysis in this section focuses on the study of biology, physics and chemistry in the:

1. Curriculum orienting conceptual framework; and
2. Curriculum content characteristics.

Again, as in Section 6.4, data will be organised under the headings:

1. Modern science as the metanarrative on the natural world
2. Scientific means of reasoning as the means of reasoning
3. 'West' and progress/sustainable development

Analyses are considered along with the data presentation. Results of the analyses will later be presented as elements answering to the posed research questions.

The analysis makes use of Government documents. The statutory Science National Curriculum for England constitutes its core. As a complement, examples will also be discussed from the QCA suggested Schemes of Work. Data will be presented regarding the National Curriculum Statement of Values, Key Stage general aims, National Curriculum for Science aims, guidelines, and attainment targets, as well as learning objectives from proposed units of the Schemes of Work.

Modern science as the metanarrative on the natural world

Curriculum orienting conceptual framework

The ideological notion of modern science as *the* metanarrative on the natural world can be found in the general understanding of modern science which is embodied in the National Curriculum for this subject. Although it is not explicitly presented, it can be found implicit in references regarding the nature of scientific knowledge, as highlighted by the example below.

> Science does not tell us everything that we want to know about life, or all we need to know. But it does provide us with the most robust information about the way the universe works that has so far become available to us. Colin Tudge, Science Writer (DfEE and QCA, 1999a, p.14)

This quotation figures in the National Curriculum for science within a framework of scientific knowledge definition. Although it limits, to a certain extent, the explaining capability of scientific knowledge, it presents it as the explanation (at least *so far*) of the natural world (defined by the universe).

Further on, one continues to find this idea associated with 'understanding' in a broader sense. That is, modern science is implicitly associated with *the* explanation above any other understandings of the natural world. Modern science is perceived to be very important in individual and collective comprehension and attitudes regarding spiritual, moral, social and cultural levels. Under the heading *Promoting pupils' spiritual, moral, social and cultural development through science*, one reads:

> Science provides opportunities to promote spiritual development, through pupils sensing the natural, material, physical world they live in, reflecting on their part in it, and exploring questions such as when does life start and where does life come from? (DfEE and QCA, 1999a, p.8)

It is not clear whether scientific explanations regarding such delicate questions are to be discussed along with others of a different nature. Moreover, it is not clear whether the scientific answers to such questions will or will not be considered as *the* answers. In fact, the nature of modern science does not seem to be considered in the quotation above. Such seems to be the case for the example below, taken from the same section:

> Science provides opportunities to promote moral development, through helping pupils see the need to draw conclusions using observation and evidence rather than preconception or prejudice, and through discussion of the implications of uses of scientific knowledge, including the recognition that such uses have beneficial and harmful effects. (DfEE and QCA, 1999a, p.8)

Scientific answers seem to be implicitly considered to be *the* answers, and thus as *the* means to combat prejudice and ignorance. Within such a framework, an idea that truth can only be obtained through scientific knowledge may develop. Consequently, and associated to it, good moral judgement and ways of life can be seen directly dependent on modern science.

Again, still in the same section regarding social development, considerations are made about the interpretations of scientific evidence. Once more, the nature of scientific knowledge regarding its explanatory characteristics does not seem to be considered.

> Science provides opportunities to promote social development, through helping pupils recognise how the formation of opinion and the justification of decisions can be informed by experimental evidence, and drawing attention to how different interpretations of scientific evidence can be used in discussing social issues. (DfEE and QCA, 1999a, p.8)

Experimental evidence may be associated with proof, although different interpretations of it can have important implications regarding social issues.

Finally, under the heading *Promoting pupils' spiritual, moral, social and cultural development through science*, one also finds references to modern science and culture. In these references modern science tends to be implicitly taken as beyond culture, that is, as a universal body of knowledge.

> Science provides opportunities to promote cultural development, through helping students recognise how scientific discoveries and ideas have affected the way people think, feel, create, behave and live, and drawing attention to how cultural differences can influence the extent to which scientific ideas are accepted, used and valued. (DfEE and QCA, 1999a, p.8)

Spiritual, moral, social and cultural development can be seen in a direct relation to modern science as the explanatory paradigm. Within this framework, the answers provided by modern science tend to be implicitly presented as affecting and defining individual and collective attitudes regarding aspects of human life beyond those of the comprehension of the natural world. Modern science may be taken as *the* knowledge.

More general references to modern science as the explanatory paradigm can be found in the curriculum attainment targets. For example, in Attainment Target 1: Scientific enquiry, Level 3, one reads:

> Pupils respond to suggestions and put forward their own ideas about how to find the answer to a question. (DfEE and QCA, 1999a, p.75)

One can argue that according to the attainment target above, pupils are not supposed to be looking for possible scientific answers. They are supposed to look for and give *the* answer to a posed question. Consequently, the scientific answers can easily be associated with the absolute answer.

Further on, in the same attainment target, however regarding a different level, that of *Exceptional performance*, one reads:

> Pupils give examples of scientific explanations and models that have been challenged by subsequent experiments and explain the significance of the evidence in modifying scientific theories. (DfEE and QCA, 1999a, p.75)

No reference is made to any discussion regarding the nature of scientific theories. Although the latter are presented as changing in time, they seem to be implicitly considered as the answers. In fact, when particular theories are considered, they appear with such a format. For example, in Attainment Target 3 – *Materials and their properties*, level 6, one reads:

> They (the pupils) recognise that matter is made up of particles, and describe differences between the arrangement and movement of particles in solids, liquids and gases. (DfEE and QCA, 1999a, p.79)

One can argue that what is expected from the students is an understanding of the corpuscular theory of matter as the explanation for the nature of matter.

These and other aspects are consistently present in all key stages of the National Curriculum, as the next paragraphs will discuss.

Key Stage 1

One can find an implicit idea of modern science as *the* metanarrative on the natural world all through this Key Stage. Great emphasis is given to scientific enquiry. Students are encouraged to ask questions. These questions are to be scientifically answered. The obtaining of answers is seen as dependent on modern science.

> During Key Stage 1 pupils observe, explore and ask questions about living things, materials and phenomena. They begin to work together to collect evidence to help them answer questions and to link this to simple scientific ideas. (DfEE and QCA, 1999a, p.16)

Implicit in this sentence one finds the promotion of the development of scientific ideas as answers. From an early age, students are encouraged to ask questions and it seems that they are directed to believe that modern science will provide *the* answers.

Key Stage 2

In Unit 5D – *Changing state* (part of the QCA Scheme of Work), one can find once more the idea of scientific explanations as the explanations. For example, among the Learning Objectives for this unit one reads:

> Children should learn that evaporation is when a liquid turns into a gas. (DfEE and QCA, 1998[5])

Similarly, in Unit 5F – *Changing sounds*, one also reads for example that:

> Children should learn that sounds are made when objects or materials vibrate. (DfEE and QCA, 1998)

In both quotations there are references to scientific theories: kinetics and wave theory, respectively. However, such references are presented as *the* explanations for the associated phenomena: physical transformation and sound production. No reference to the notion of theory is considered. Both kinetics and wave theory are contemporary scientific explanations. However, the ways by which they are presented in the curriculum can make them appear as definitive explanations and thus, as the truth. Such theories are the result of continuous change in the ways by which matter and sound have been scientifically understood in time. Neither kinetics theory nor wave theory are capable of scientifically answering all questions within their fields of study, let alone provide the definitive truth.

In Unit 6B – *Micro-organisms* one reads:

Children should learn that scientific ideas about diseases are based on evidence. (DfEE and QCA, 1998)

The importance attributed to evidence in the form of proof regarding scientific explanations has already been suggested. In the objective above there seems to be an implicit promotion of scientific concepts of health and disease as *the* definitive concepts. Moreover, evidence is considered in such a way that it may be understood as proof of the validity of such concepts.

In Unit 6E – *Forces in action*, one can find once more examples of scientific explanations implicitly presented as the explanation. This unit exposes gravitational theory as the answer. For example, one reads that:

Children should learn:
- that the Earth and objects are pulled towards each other; this gravitational attraction causes objects to have a weight;
- that weight is a force and is measured in newtons. (DfEE and QCA, 2000)

No reference is made to gravitational theory as a scientific theory, and thus as a scientific explanation. Even when references are made to models, they do not generally affect the transmitted image of modern science as the explanation. Interestingly, such references are particularly found in relation to physics and chemistry. Regarding issues of biology, explanations tend to be entirely presented as *the* explanations. For example, in Attainment Target 4 – *Physical processes*, Exceptional Level, one reads:

They (the pupils) understand how models are useful in explaining physical phenomena. (DfEE and QCA, 1999a, p.81)

The ideology of modern science regarding its explanatory nature seems to be embodied within the National Curriculum for science in terms of aims, guidelines, objectives and orientation. Scientific explanations tend to be presented as *the* explanation. Hardly any references are made to the nature of theories, principles and scientific concepts. Moreover, these are generally not considered outside physics and chemistry. Modern science tends to be implicitly presented as the means to obtain answers. Such answers may involve issues beyond the natural world. Modern science tends to be considered as fundamental for spiritual, moral, social and cultural development within a framework of universalism.

Curriculum content characteristics

Key Stages 1 and 2

In Unit 1D – *Light and dark*, regarding children's use of vocabulary, one reads:

> In this unit children will have the opportunity to use expressions giving reasons using 'because'. (DfEE and QCA, 1998)

The example above can imply that since Year 1 of science education, children are encouraged to use and understand scientific explanations as the explanation. While giving a reason, they are encouraged to use the word 'because', which can acts as *the* answer. This is also the case for Unit 1E – *Pushes and pulls*. Both units are directly related to scientific knowledge within physics. Such knowledge seems thus to be implicitly presented as the knowledge.

Again, in Year 2, one finds similar aims. For example, in Unit 2A – *Health and growth* – one reads:

> In this unit children will have opportunities to use expressions of reason using 'because'. (DfEE and QCA, 1998)

Particularly considering Key Stage 2, the following aspects deserve detailed attention.

In the theme *Scientific enquiry*, under the heading *Ideas and evidence in science* one reads:

> Pupils should be taught that science is about thinking creatively to try to explain how living and non-living things work, and to establish links between causes and effects. (DfEE and QCA, 1999a, p.21)

Implications may derive regarding an understanding of modern science as *the* means to explain the surrounding world and the ways by which it operates.

In the theme *Life processes and living things*, particularly under the heading 'Humans and other animals' one finds scientific understandings of the human body, diet and health. Again, these tend to be presented as *the* concepts. No reference is made to other understandings of these notions (DfEE and QCA, 1999a).

Similarly, one can find the presence of the ideology of modern science regarding it as the metanarrative on the natural world in the presentation of physical concepts as *the* definitive concepts. For example:

> Pupils should be taught that objects are pulled downwards because of the gravitational attraction between them and the Earth. (DfEE and QCA, 1999a, p.26)

Gravitational theory can be understood as *the* explanation.

Key Stage 3

The theme *Life processes and living things* is, in this Key Stage, mainly dedicated to the development of the concept of organism. Particular attention is given to humans as organisms. Within this last theme, again, scientific explanations tend to be presented as explanations, regarding the whole functioning of the human body. This applies also to the concept of health. No references are made to any other understandings of health. For example, one reads:

> Pupils should be taught:
> - that the use of alcohol, solvents, and other drugs affects health;
> - how the growth and reproduction of bacteria and the replication of viruses can affect health, and how the body's natural defences may be enhanced by immunisation and medicines. (DfEE and QCA, 1999a, p.31)

No references are made to other understandings of disease and cure than the ones scientifically defined.

Under the heading *Variation, classification and inheritance*, particularly regarding Inheritance, one reads:

> Pupils should be taught that selective breeding can lead to new varieties. (DfEE and QCA, 1999a, p.31)

Variation and diversity are presented within a scientific framework within a usage of language that may lead to an understanding of them as *the* explanation.

Once more, one seems to find the presence of the ideology of modern science in the ways by which theories are presented as the explanation. For example, elements from gravitational theory are presented as follows:

> Pupils should be taught:

- That the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth. (DfEE and QCA, 1999a, p.34)
- About the movements of planets around the Sun and to relate these to gravitational forces. (DfEE and QCA, 1999a, p.35)

No reference is made to the notion of scientific theory. In the example above Gravitational Theory is presented as *the* answer to the questions on falling objects and to those on planetary movements. Newtonian theory and relativity theory constitute two interpretations of notions of time, space and forces. However, the first of these theories is presented in the example as the answer. One theory is chosen and presented as the means to obtain the truth. The other is completely disregarded. In fact, what really is disregarded is the nature of scientific theories and their explanatory limits. In the objectives above not only is the nature of scientific theories not considered, but also one theory is preferred to another and presented as the truth. The ideology of modern science is embedded in the objectives above.

A similar case is found regarding kinetics theory. For example:

> Pupils should be taught how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation. (DfEE and QCA, 1999a, p.36)

In this example, kinetics theory is presented as the explanation.

Key Stage 4 – Single Science and Double Science[6]

One can find the ideology of modern science regarding the ways by which theories are presented as answers. This is the case for evolution theory, for atomic theory, and for wave theory. For example:

Evolution

Pupils should be taught:

- that the fossil record is evidence for evolution;
- how variation and selection may lead to evolution or to extinction. (DfEE and QCA, 1999a, p.40)

Pupils should be taught:

- that atoms consist of nuclei and electrons;
- how the reactions of elements depend on the arrangement of electrons. (DfEE and QCA, 1999a, p.41)

Pupils should be taught:

- about the reflection and refraction of waves, including light and sound as examples of transverse and longitudinal waves;
- that the electromagnetic spectrum includes radio waves, microwaves, infrared, visible light, ultra-violet waves, X-rays and gamma rays;
- that longitudinal and transverse earthquake waves are transmitted through the Earth, and how their times and paths provide evidence for the Earth's layered structure (DfEE and QCA, 1999a, p.55)

Following a similar pattern to the one already discussed regarding the general orientation of the curriculum, arguments can be made for the presence of the ideology of modern science in terms of its explanatory nature. Theories are presented as the explanations. Even if discussions are considered regarding scientific knowledge production, those discussions do not explicitly involve issues on the nature of scientific knowledge. Consequently, in the whole science curriculum, regarding issues of biology, chemistry and physics one can find the presence of the ideology of modern science in terms of an understanding of scientific explanations as the metanarrative on the natural world.

Scientific means of reasoning as the means of reasoning

Curriculum orienting conceptual framework

Within all Key Stages basic importance and value seems to be given to scientific methods as the means of reasoning. *Scientific enquiry* constitutes one of the four study areas in the National Curriculum for science. It is common to all Key Stages and it inter-links with the other three study areas. The importance attributed *to Scientific enquiry* is not limited to the study of modern science. In the section 'Learning across the national curriculum', under the heading 'Promoting skills through science' one reads:

> Science provides opportunities for pupils to develop the key skills of problem-solving, through finding ways to answer scientific questions with creative solutions. (DfEE and QCA, 1999a, p.8)

Although problem-solving is mostly considered in a direct relation with the search for scientific answers, it is implicitly taken as a fundamental means of reasoning to be used beyond such a search. Problem-solving skills developed in science education can be seen extended to all other subjects across the curriculum. One can argue that implicit in this idea is the notion of scientific means of reasoning (here associated with problem-solving) as *the* means of reasoning.

This notion is again presented under the heading 'Promoting other aspects of the curriculum', also common to all Key Stages. Under this heading one finds the following:

> Science provides opportunities to promote thinking skills, through pupils engaging in the processes of scientific enquiry. (DfEE and QCA, 1999a, p.9)

Thinking skills can be understood in a direct association to scientific means of reasoning. 'One learns how to think if one learns the scientific enquiry, by developing its associated skills'. Similarly with the case for solving problems regardless of their nature.

> Studying science teaches us to be good at analysis and helps us to make complex things simple. Brendan O'Neill, Chief Executive, Imperial Chemical Industries PLC (DfEE and QCA, 1999a, p.14)

> Scientific method is about developing and evaluating explanations through experimental evidence and modelling. This is a spur to creative and critical thought. (DfEE and QCA, 1999a, p.15)

The ideology of modern science regarding scientific method is made explicit in these orienting guidelines. Thinking skills and the provision of answers are perceived as being directly related to scientific means of reasoning. Moreover, a single scientific method is explicitly considered even if discussions within philosophy of science have been debating and disputing scientific methodology and the existence of a singular scientific method (see for example, Feyerabend, 1992). In fact, as will be discussed, a process of scientific knowledge production, which is based on the application of a particular method following specific and pre-determined steps, can be found in the study area *Scientific enquiry*. Again, the existence of such a method has been contested both in philosophy and history of science.

Key Stage 1

Following the general orientation regarding *scientific enquiry*, one reads that in this Key Stage:

> Teaching should ensure that scientific enquiry is taught through contexts taken from the sections on life processes and living things, materials and their properties and physical processes. (DfEE and QCA, 1999a, p.16)

That is, scientific enquiry, understood as a singular method, should be taught in all areas of study defined for the Key Stage.

> Pupils should be taught that it is important to collect evidence by making observations and measurements when trying to answer a question. (DfEE and QCA, 1999a, p.16)

Great importance is given to evidence and evidence collection. One may accept that implicit in this assumption is a stressing of the idea of evidence as proof.

In the study area *Life processes and living things*, variation and classification are considered very important skills to be developed in the students. They are particularly taken in a binary form, in terms of similarity and difference. They specifically refer to human beings.

> Variation and classification
>
> Pupils should be taught to:
>
> a) recognise similarities and differences between themselves and others, and to treat others with sensitivity;
>
> b) group living things according to observable similarities and differences. (DfEE and QCA, 1999a, p.17)

Although reference is made to treating others with sensitivity, classification based on difference and similarity can be understood as the means to understand human diversity. Other forms of understanding of the latter are disregarded.

Classification is again reinforced regarding materials, in the study area *Materials and their properties*.

Grouping materials

Pupils should be taught to use their senses to explore and recognise the similarities and differences between materials. (DfEE and QCA, 1999a, p.18)

Understanding diversity in general – plants, animals, materials, human beings – is transmitted within a classification framework based on difference and similarity. This framework seems to be, at the same time, presented as *the* framework for understanding diversity.

Key Stage 2

Reinforcement of detail in teaching scientific enquiry is a continuing characteristic throughout the various key stages. For example, in one of the proposed learning units of QCA Scheme of Work for Science[7], one reads the following suggested learning objectives:

- to obtain evidence to test scientific ideas;
- to plan and carry out a test safely;
- to decide whether the test was fair. (DfEE and QCA, 1998)

Particular attention is paid to the notion of fairness. This has been the case since Year 1. Fairness is associated with skills such as comparison. Fairness is understood in relation to scientific criteria, which seems to be taken as *the* criteria.

Key Stages 3 and 4

Again one finds a stress on teaching scientific enquiry in these Key Stages. And again, scientific means of reasoning tend to be implicitly taken by *the* means of reasoning. A similar pattern, which is described above, is maintained for all Key Stages regarding the objectives defined for scientific enquiry. From Key Stage to Key Stage, increasing detail regarding the involved skills is considered. The same applies to the definition of scientific enquiry as a singular method (DfEE and QCA, 1998, 1999a).

A great deal of attention is paid to scientific methods in the National Curriculum for science. In fact, a particular scientific method is considered and one can argue that it is often presented as the means of reasoning. Problem-solving, thinking skills, thinking creatively are all seen in association with the development of this scientific method. The method is taught in detail, progressively, from Key Stage to Key Stage. Skills such as classification and binary criteria selection are reinforced as the means to understand diversity in general. Consequently, it is possible to consider that in terms of the general orientation of the curriculum, the idea of scientific means of reasoning as the means of reasoning is often stressed. Problematic consequences of this may be the promotion of classification as *the* means to understand diversity in general and human diversity in particular.

Curriculum content characteristics

Key Stage 1

In this Key Stage, teaching modern science values knowledge and method in equal measures. *Scientific enquiry* is presented in a traditional structure defined by the following sequence:

1. Planning
2. Obtaining and presenting evidence
3. Considering evidence and evaluating (DfEE and QCA, 1999a, p.16)

It is plausible to consider that from their first contact with science education, children are exposed to the promotion of a way of understanding the natural world, which attempts to shape their means of reasoning within a particular framework. In fact, the development of scientific means of reasoning is not seen only in relation to modern science. For example, under the heading *Considering evidence and evaluating*, regarding the skill comparison, one reads:

> Make simple comparisons (for example, hand span, shoe size) and identify simple patterns and associations. (DfEE and QCA, 1999a, p.16)

Also, in the QCA's suggested units for science teaching regarding this Key Stage, particularly in Unit 1A – *Ourselves*, one finds an attribution of particular importance to classification as the means of organising variety. Particular attention is given to diversity and difference among human beings. Selection variables are defined and categorisation is promoted. Among the suggested criteria one finds that of eye colour and other, to be later on - in other Key Stages - related to inherited characteristics (DfEE and QCA, 1998). From an early age, the notion of human categorisation as *the* means of understanding human diversity seems to be promoted among students.

Again, in Unit 2 – *Growing Plants*, one finds a similar emphasis on categorisation as *the* means for understanding diversity. Moreover, one also finds the idea of constructing difference in a dual form:

> This unit introduces children to the idea of plants as living things, which grow and change. Children should become aware of similarities and differences in plants. (DfEE and QCA, 1998)

And again, classification is stressed when materials are studied (DfEE and QCA, 1998).

Emphasis on 'either/or' understandings of difference is once more considered regarding the study of movement in Unit 1E – *Pushes and Pulls*:

Children should learn similarities and differences between the movement of different objects. (DfEE and QCA, 1998)

Implicitly, one finds the idea of understanding variety in general and thus human variety in particular, defined in opposing terms by similarity and difference.

Implicit notions of scientific means of reasoning as *the* means of reasoning can again be found in Year 2, Unit 2B – *Plants and animals in the local environment.* In this unit, stress is put on the development of answers through the application of a scientific framework on reasoning. One reads:

Experimental and investigative work focus on:
- turning ideas into questions that can be investigated;
- presenting results;
- drawing conclusions. (DfEE and QCA, 1998)

Key Stage 2

In the theme 'Scientific enquiry' and under the heading *Ideas and evidence in science* one finds the following:

Pupils should be taught that science is about thinking creatively (...). (DfEE and QCA, 1999a, p.21)

Embodied in the above content one can find the ideology of modern science regarding the latter as the means of reasoning. 'Thinking creatively may be seen as thinking scientifically'.

Likewise in Key Stage 1 continuing stress is put on teaching and learning scientific methods within a similar framework to that considered before (DfEE and QCA, 1999a). And again, as in Key Stage 1, particular attention is given to classification as *the* means of understanding diversity – variety. Under the heading *Variation and classification* one reads:

> Pupils should be taught:
>
> a) to make and use keys;
> b) how locally occurring animals and plants can be identified and assigned to groups;
> c) that the variety of plants and animals makes it important to identify them and assign them to groups. (DfEE and QCA, 1999a, p.24)

The establishment of selection variables and consequent classification is implicitly presented as an indispensable form of dealing with diversity. Concern with classification is also presented regarding materials (DfEE and QCA, 1999a).

Progressively through all the years, more detail is considered on teaching scientific methodology mainly as a singular method. No changes seem to occur regarding its ideological understanding. For example, in Unit 4E – *Friction*, one reads:

> Experimental and investigative work focus on:
>
> - deciding what evidence should be collected when planning and carrying out a fair test;
> - looking for patterns in results, interpreting and suggesting explanations for these. (DfEE and QCA, 1998)

In fact, all units proposed in QCA Scheme of Work for Key Stages 1 and 2 tend to reinforce the notion of scientific methods as *the* means of reasoning. As regards the several thinking skills defined in the National Curriculum, one finds that out of a total of 38 proposed units:

- 18 involve *information-processing skills*;
- 15 involve *reasoning skills*;

- 21 involve *enquiry skills*;
- 12 involve *creative thinking skills*;
- 14 involve *evaluation skills*. (DfEE and QCA, 2000)

Particular emphasis is given to enquiry skills, which are the ones more directly related to the scientific methodology:

> These enable children to ask relevant questions, to pose and define problems, to plan what to do and ways to research, to predict outcomes and anticipate consequences and to test conclusions and improve ideas. (DfEE and QCA, 2000, p.8)

Consequently, scientific enquiry is considered an inner part of all units.

Key Stage 3

Following the continuing line on teaching scientific methods, one finds in this Key Stage an increasing emphasis on more detailed elements of the scientific methodology. In fact, this is presented under the implicit form of a method, with associated steps. The idea of a scientific method has already been observed in the general aims and orienting guidelines. Again, similar means of organising skills are defined:

1. Planning
2. Obtaining and presenting evidence
3. Considering evidence
4. Evaluating (DfEE and QCA, 1999a)

Once more emphasis is put on modern science's predicting role, and on the association between evidence and proof. The production of scientific knowledge is presented in a linear way: planning, experimenting and evaluating evidence. The idea behind this seems to be one of, 'if one follows such a procedure one will then be able to obtain scientific knowledge'. However, the existence of a single scientific method is a controversial issue in modern science (see for example Feyerabend, 1992). Controversies have also been developed with regard to the ways by which scientists produce scientific knowledge (see for example Fuller, 2000). Nonetheless, one does not find any references to any of these controversies. On the contrary, one finds a method being presented as the means to obtain the truth. Evidence is implicitly associated with proof. The nature of evidence and evaluation is not considered. Associating evidence with proof tends to imply the acceptance of scientific knowledge as the truth.

As in previous Key Stages, one can find particular attention given to classification as the means to understand diversity. Environmental and inherited factors are presented as two fundamental means of categorisation of variation in any given species. That idea is then applied for human beings.

> Variation, classification and inheritance
>
> Pupils should be taught: (...)
>
> a) about environmental and inherited causes of variation within a species;
>
> b) to classify things into major taxonomic groups. (DfEE and QCA, 1999a, p.31)

Invariably human difference tends to be implicitly perceived within such a classificatory framework.

Key Stage 4 – Single Science and Double Science

Following the framework used in previous Keys Stages for the development of skills associated with scientific methodology, one finds again a continuing emphasis on detailed aspects of such a methodology. One also finds the idea of means of reasoning defined by scientific means of reasoning embedded in the frame of problem-solving. For example:

> Pupils should be taught to use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy. (DfEE and QCA, 1999a, p.37)

One can find the idea of scientific means of reasoning as the means to obtain the truth in this objective. One finds the idea of 'understanding how to turn ideas into a form that can be investigated'. This is associated with the idea of 'learning how to use scientific knowledge'. There is no reference to the nature of these ideas. Can any idea be transformed in such a way that it can be investigated? Will investigation always provide the truth? These are questions that one can pose when reading the objective above. The latter gives no response to them. This being the case, it is possible to argue that implicit in this objective is the idea that developing an investigation, following the scientific method, will provide explanations to every problem that one may pose. This is so, as any idea is acceptable to be investigated, as long as it is transformed in such a way that allows the application of the scientific method.

In this objective one can also find an implicit emphasis on understanding problems within controlled conditions. That is, parts of reality are separated from the whole, and understanding of such a reality comes in isolation: 'turning ideas into a form that can be investigated'. The isolation of a part of reality for its understanding is a fundamental characteristic of the scientific way of comprehension. The ideology of modern science with regard to means of reasoning, may also contribute to attaching a superior value to such a characteristic in relation to other analytical forms aimed at understanding reality.

Following a similar pattern to that already seen regarding the curriculum general orientation, the ideology of modern science concerning means of reasoning can also be found in curriculum content. A scientific method is often presented to the students as *the* means to understand the natural world. As it is directly perceived as the way to solve problems, its ability to provide *the* answers is implicitly taken beyond the limits of the natural world. Partial understandings of reality are also generally seen as the means to provide answers. Particular attention is given to skills such as classification. The latter tends to be taken as *the* way to understand diversity. At the same time, diversity is presented in an organisational form which values a binary understanding of it defined in terms of difference and similarity. One can argue that the whole of the science curriculum is embedded in the ideological notion of scientific means of reasoning as the definitive means of reasoning.

'West' and progress/sustainable development

Curriculum orienting conceptual framework

The notion of sustainable development is a fundamental one in contemporary English education as was previously discussed in this chapter. It is present across the National Curriculum, and it is particularly considered in science education. Within the considerations made, one does not find, however, references to a de-construction of notions of modern science's supremacy due to its association with progress. Under the heading *Promoting other aspects of the curriculum*, one reads:

> Science provides opportunities to promote education for sustainable development, through developing pupils' skills in decision-making on the basis of sound science, the exploration of values and ethics relating to the applications of science and technology, and developing pupils' knowledge and understanding of some key concepts, such as diversity and interdependency. (DfEE and QCA, 1999a, p.9)

Further on, one also reads:

> Pupils recognise the cultural significance of science and trace its worldwide development. (DfEE and QCA, 1999a, p.15)

The sentence seems to be embodied in ambiguous elements. The expression *cultural significance* does not explicitly or implicitly addresses the cultural nature of modern science. That is, such a sentence does not necessarily involve any de-construction of the cultural roots of modern science, of 'Western' appropriation of scientific knowledge and of the consequences of the worldwide development of modern science.

Within the section *Learning across the national curriculum*, particularly under the heading 'Promoting other aspects of the curriculum', one finds the attribution of great importance to the relation between modern science, work, and economic development (DfEE and QCA, 1999a).

> Science provides opportunities to promote:
> - enterprise and entrepreneurial skills, through pupils learning about the work of scientists and of the ways in which scientific ideas are used in technological products and processes;
> - work-related learning, through studies of science-based industrial and commercial enterprises and through contacts with local scientists, engineers and workplaces. (DfEE and QCA, 1999a, p.9)

The example above does not quite define what is supposed to be the work of scientists. It associates scientific development with technology and enterprise. However, one does not find any reference to political and social issues associated with modern science and enterprise. One does not find any references to how scientific and technological development affects different groups within society; how economic development is dependent of scientific development and how the two relate to issues of power in societies, just to consider a couple of examples.

One can see implicit in the curricular example above the idea that: (i) ways of working in modern science can promote enterprise; and (ii) economic development is directly related to scientific development. Implications of this for different societies and for different groups are disregarded.

> Through science, pupils understand how major scientific ideas contribute to technological change – impacting on industry, business and medicine and improving the quality of life. (DfEE and QCA, 1999a, p.15)

This example builds on the previous one. Modern science is perceived within a context of social and economic improvement, which is hardly questioned even if potential for negative results is considered. The notion of the *impact* of modern science in society is considered, but this impact is not clearly defined. Furthermore, one can even argue that implicit in the example above is a notion of quality of life supported by scientific and technological development. The question however, is whether such concept of quality of life has a universal nature and if it is universally applied? No reference to such issues is considered. Change is presented in the dependency of modern science and technology, associated with the improvement of quality of life in general and absolute terms.

Key Stage 2

As part of the QCA Scheme of Work for Science one finds a unit called *Enquiry in environmental and technological contexts* (DfEE and QCA, 2000). Interestingly, in spite of the title, this unit specifically focuses on scientific enquiry. Its main aim is to cement the various steps of 'the scientific method' from posing a question to reaching evidence and concluding from it. No particular social or economic analyses are considered regarding modern science and societies.

References to modern science and sustainable development are found as above presented. The omission of concrete proposals for the study of modern science within a social and cultural perspective can be seen as a reflection of a specific understanding of the role of modern science for sustainable development. Within such an understanding, this role is supported by economic aims and it can be characterised by the teaching of scientific knowledge and skills in order to obtain a scientifically prepared workforce. De-constructions of the importance of modern science in the attribution of cultural supremacy to the 'West' tend to be excluded from the curriculum general aims. So is the case for a de-constructing of the participation of modern science in the definition of economic and social understandings of cultural difference.

Modern science as a means for sustainable development tends to be a pervasive idea. Yet, no references are made to political issues associated to sustainable development and to modern science. 'Western'-based notions of social and economic development as well as those on quality of life appear in the curriculum within a general and universal framework. Different groups, with different needs, both within a society and part of different societies are not considered. The concept of sustainable development seems to appear in the curriculum within a culture-free framework, which is a characteristic of the ideology of modern science.

Curriculum content characteristics

Key Stages 1 and 2

Regarding the *Breadth of study* for these Key Stages, one reads:

> During the key stage, pupils should be taught the knowledge, skills and understanding through looking at the part science has played in the development of many useful things. (DfEE and QCA, 1999a, p.20 and p.27)

Hardly any consideration is given to other implications of scientific development. 'Useful things' tends to imply an understanding of modern science within an ideological framework of progress. At the same time the relative nature of the term *useful* is not discussed.

Key Stage 3

Within the theme *Living things and their environment* one finds a section entitled 'Adaptation and competition'. In it one reads that the pupils should be taught

> about ways in which living things and the environment can be protected, and the importance of sustainable development. (DfEE and QCA, 1999a, p.31)

One can argue that implicit in this sentence is a notion of sustainable development which is framed within a set of adaptation and competition. The curriculum is ambiguous in relation to what is expected of students to learn. However, the concept of sustainable development is maintained mostly within the ideological framework of modern science.

Within the section *Breadth of study* one reads:

> During the key stage, pupils should be taught the Knowledge, skills and understanding through considering the benefits and drawbacks of scientific and technological developments, including those related to the environment, health and quality of life. (DfEE and QCA, 1999a, p.36)

Although references are made to discussing scientific and technological drawbacks influencing the environment, health and quality of life, no specific reference is made to any de-construction of the social and economic concept of progress or even that of sustainable development. In fact, the latter is implicitly taken as a process in which modern science plays a positive role.

Key Stage 4 – Single Science and Double Science

Particular attention is again given to the notion of sustainable development in association with modern science in this Key Stage. Again, issues of scientific and technological impact on society are considered. However, it is not explicit which societies are at stake (are they 'Western' societies?, are they all societies?) or the relation between them and modern science. Sustainable development is within the theme *Adaptation and competition* in both Single and Double Science.

> Pupils should be taught:
>
> - how the impact of humans on the environment depends on social and economic factors, including population size, industrial processes and levels of consumption and waste;
> - about the importance of sustainable development. (DfEE and QCA, 1999a, p.40 and p.50)

No reference is made to which societies are involved, to their eventual different roles in sustainable development, to their relations of interdependency, established on the basis of scientific and technological development.

As was the case regarding the curriculum orienting framework, one can find in curriculum content the ideology of modern science in association with notions of progress and sustainable development. Sustainable development is mainly presented in the dependency of modern science. Modern science's participation is presented in a positive way even if notions of the former's *impact* on societies are considered. There are no clear references to how social and economic constructions of difference operate within a framework of sustainable development. One can thus argue that ideological notions of progress and sustainable development, as presented in the ideology of modern science, are embedded in the National Curriculum for science.

Answering Elements to the Research Questions

From the analyses above, answering elements for the research questions posed in Chapter 5, Section 5.3, will be put forward as was the case with Section 6.4 of the previous chapter.

Research Question 1

How does the ideology of modern science, if present, contribute to a cultural evaluation of different metanarratives on the natural world and, consequently, of different cultures, through the science curriculum?

The analyses of both general curriculum orientation and content indicated the presence of the ideology of modern science in terms of its explanatory nature in the English National Curriculum for science. Several examples were provided regarding the presentation of scientific theories as *the* explanation of natural phenomena. The presentation and analysis of data also highlighted the fact that hardly any discussions on the nature of scientific knowledge were included. Modern science tends to be presented as beyond culture. References are made to how different cultures may accept scientific knowledge differently, but no discussion is clearly proposed on the cultural nature of scientific knowledge. This tends to be a curriculum characteristic consistently found from Key Stage 1 to Key Stage 4.

Through the progressive study of modern science, a particular model of the latter is being transmitted. According to the analysis, this model seems to support the development of a notion of modern science as *the* explanatory paradigm on the natural world. If that is the case, other forms of explanation are under-valued when compared to modern science.

As modern science is implicitly associated with 'Western' culture, its acceptance as the explanatory paradigm implies the acceptance of 'Western' understandings of the world as *the* correct and universal ones. 'Western' worldviews become then perceived as culture-free and therefore, universal. Ideas of cultural superiority may be reinforced in English students.

Since modern science is perceived as fundamental in students' moral, spiritual, social and cultural development, the latter is embodied in all aspects of individual and collective life. Scientific knowledge presented as *the* worldview can reinforce those 'Western' means of understanding and living which are directly related to moral, spiritual, social and cultural aspects. At the same time it can imply an assimilation of such understandings and ways of living by students from non-'Western' cultural backgrounds. In broader terms, one can argue that it can contribute to the development of processes of 'Western' cultural imperialism. In other words, the presence of the ideology of modern science in the English National Curriculum for science is possibly contributing to an evaluation of cultures, which tends to attribute superior value to 'Western' culture.

Research Question 2

How does the ideology of modern science, if present, contribute to a cultural evaluation of different means of reasoning, and consequently of different cultures, through the science curriculum?

The analyses of the above section pointed out the presence of the ideology of modern science in the English National Curriculum for science regarding the identification of the scientific methodology as *the* means of reasoning. Great emphasis is put on the development of skills which are directly associated with scientific methods. Problem-solving is a prominent example.

As problem-solving is considered fundamental in everyday individual and collective life outside the limits of modern science, one can argue that skills associated with scientific means of reasoning can be understood and accepted as *the thinking skills.*

Scientific Enquiry constitutes one of the four statutory areas of study for all Key Stages. In fact, its presence is found in the other three study areas. After being taught *scientific enquiry* students are expected to learn how to ask questions and find *the* answers, 'proved' by evidence. In fact, what this area of study considers is the teaching of a step-based method of finding answers to posed problems. This method is presented as *the* scientific method and hardly any discussion of its nature is made or mentioned.

The existence of scientific method is a controversial issue in philosophy of science. However, the notion of *the* scientific method tends to be presented in the curriculum in a universal and unquestioned form. As this method is taken as *the* definitive method for solving problems, its associated means of reasoning can thus be considered superior to any others. The scientific methodology is ideologically associated with the 'West'. Consequently, what is at stake is a very possible attribution of a superior value to 'Western' means of reasoning in relation to any others. Students from 'non-Western' cultures may then be confronted with a process of assimilation regarding their understanding and use of skills associated with the scientific methodology.

Categorisation and classification are among the skills taught in association with the 'scientific method'. These skills are generally presented as *the* means to understand variety, which characterises materials, animals, plants and human beings. Quite often, processes of classification appear defined in a binary opposing form, defined in terms of similarity and difference. Consequently, other forms of understanding diversity, particularly human diversity may be under-valued and unrecognised. One can argue then, that students implicitly learn one form of understanding diversity as *the* universal and superior form.

Overall, the presence of the ideology of modern science regarding scientific means of reasoning in the English National Curriculum can be contributing to a cultural evaluation, which attributes superior value to 'Western' culture. Moreover, at the classroom level, it may be implying a forced process of acculturation regarding the development of means of reasoning among students of a 'non-Western' origin. These may be implicitly forced to abandon and deny other means of reasoning and to shape their intellectual skills according to the structure of scientific thinking.

Research Question 3

How does the ideology of modern science, if present, contribute to the definition of 'Western' means of understanding cultural difference as *the* means of understanding such a difference, via the science curriculum?

Elements of the ideology of modern science were found in the English National Curriculum for science regarding understandings of modern science as *the* metanarrative on the natural world, and regarding scientific means of reasoning as *the* means of reasoning. Diversity and variety are discussed in the curriculum by making use of scientific means of reasoning, particularly focusing on skills such as classification, categorisation and comparison. Consequently, the resulting understandings of diversity can be perceived as the 'true' ones, because they are 'scientific'. Although no references are made to cultural diversity, the acceptance of the existence of a specific set of 'true' means of understanding variety implies the use of the same means, or at least the same framework, for understanding cultural difference. The results obtained can thus be understood as scientific and consequently as the 'truth'.

Research Question 4

How does the ideology of modern science, if present, contribute to the development of a comprehension of cultural evolution that privileges the 'West', through the science curriculum?

Modern science is considered a basic element for sustainable development. Although attention is given to modern science and environmental and ethical issues, since an early age students learn that modern science provides good and useful things. Almost any reference is made to the role of modern science in the establishment of social and economic relations between different parts of the world. Hardly any discussions take place, either, as to which individuals benefit and which suffer from scientific and technological development. Modern science's ability to improve the quality of life is generally taken as a universal characteristic, without any specific de-construction of economic and political uses of scientific and technological knowledge. Consequently, one can argue that the English National Curriculum for science tends to not de-construct the participation of modern science in social and economic constructions of difference.

Moreover, implicit in the considerations of modern science and sustainable development one finds traditional images of the former in terms of the ideological concept of 'progress'. Although the relation between modern science and environmental and ethical issues, for example, deserves particular attention, the ideologically superior importance accorded to modern science in terms of social and economic evolution is still present. As modern science is ideologically associated with 'Western' culture, social and economic progress, when seen in the dependency of scientific knowledge, implies the attribution of a superior value to the 'West'. In order words, societal and cultural evolution tend to be presented in association with scientific development, as 'owners' of scientific knowledge are (or at least can be) the 'owners' of progress/sustainable development.

English education gives a great deal of importance to science education. This mostly resulted from persistence of an understanding of science education as a means to economic improvement via the formation of a scientifically and technologically skilled working force. Contemporary science education is at the heart of an educational understanding of the value of skills for life and employability in information-technology societies. Consequently, great emphasis is put on the study of scientific methods. Science education is fully embodied in a problem-solving orientation. The latter is not only specific to this subject but also extended to other areas of understanding. However, as the curricular study pointed out, the ideology of modern science tends to be present in the whole curriculum. Consequently, an emphasis on scientific methodology as the means of reasoning may be contributing to a cultural empowerment of the 'West'. This can apply to other aspects of the ideology modern science also present in the English National Curriculum for science.

7.5 Conclusion

Contemporary political discourse in England makes constant reference to issues of ethnic and cultural diversity. This is mainly the result of demands for recognition from various non-dominant groups, along with an exposure of various forms of racism operating in the English society. English politics has accompanied that of the UK, and thus it saw the process of Scottish devolution along with the failure of assimilating and integrating policies directed to external non-dominant groups. At the heart of the debate lay revivals of ethnic identities of which those of Britishness and Englishness acquired particular importance.

A great deal of political debate in contemporary UK has been defined by needs of state cohesion. Britishness has been revived so as to fulfil such needs. Many elements have contributed to define this identity. One of those is scientific and technological development of which British people are expected to feel proud.

The importance attributed to scientific and technological development mainly derives from an understanding of modern science within the latter's ideology. Ownership of scientific knowledge is generally perceived as a means of cultural superiority because modern science is understood as the metanarrative on the natural world, as the source for answers and as the means of progress/sustainable development.

In England, state science education is now defined by a National Curriculum. This subject, as well as all others, is now part of a centralised educational system. English education underwent substantial change, of which centralisation and standardisation are two main results. Contemporary English education is defined not only by a National Curriculum, but also by educational results obtained after centralised attainment standardisation. Particular attention is given to the development of skills. The political ideology behind this is that of the need for a skilled working force in an information-technology society. According to this ideology, once an individual is skilled enough, he/she will find his/her working place and consequently, his/her societal place. It is the notion of 'employability for all', as if having a job could immediately guarantee a social and political place in a culturally diverse society, in which skin-colour, cultural and institutional racism are evident.

The development of skills is particularly emphasised in English science education. At the basis of English science education lie mainly aims of an economic nature. In fact, this subject is looked at as the privileged one regarding such an issue. This is so because of the value attributed to scientific methodology. Consequently, scientific enquiry is one of the bases of English science education. Moreover, this type of enquiry is expected to be developed in other educational subjects.

The curricular study in this chapter pointed out that contemporary physics, chemistry and biology curricula in English education tend to be embedded in an understanding of the scientific methodology as the means of reasoning. This is a specific characteristic of the ideology of modern science. In fact, the study indicated that this is not the only characteristic of such an ideology present in the curriculum. One can also find an understanding of modern science as the provider of answers, as the metanarrative on the natural world, and as the basic means for sustainable development. These findings are in agreement with the political understandings of modern science in and for English society and their relationship with the economy. They point out to the eventual socialising role of science education regarding cultural diversity.

As discussed in previous chapters of this thesis, the promotion of the ideology of modern science can be a contributor to 'Western' cultural imperialism. Consequently, the English science education curriculum may not be contributing to a fairer and less racist culturally diverse society. This conclusion is rather similar to that obtained after the study of Portuguese science education. A comparison between the two studies is the object of the next chapter in which the nature of such a similarity will be discussed in detail.

Chapter 8

Comparative Analysis

8.1 Introduction

This chapter consists of a comparative discussion of the findings of Chapters 6 and 7. It has two main sections and a concluding one. The first section presents a general comparison between the findings. It is oriented by the comparative principles put forward in Chapter 5. Consequently, it will involve comparing issues relating to Portuguese and English understandings of modern science and cultural diversity; Portuguese and English comprehension of state education; and Portuguese and English reflections on science education informed by the respective understandings of cultural difference and the ideology of modern science.

The second section in the chapter consists of an analysis of the comparison results, making use of specific characteristics of each country, as presented in Chapters 6 and 7.

8.2 General Comparison

Each of Chapters 6 and 7 presented an analysis of understandings of cultural diversity in the Portuguese and English societies. They also discussed understandings of modern science in these two countries. Finally, they presented a curricular analysis of Portuguese and English science education. This analysis looked at the reflections both of understandings of cultural diversity and of modern science in science education. Particularly, it focused on the presence and characteristics of the ideology of modern science in the science curriculum in relation to understandings of cultural difference. This section considers a general comparison of the results of Chapters 6 and 7. The comparison is organised under the comparative principles put forward in Chapter 5.

Portugal/England, Cultural Diversity, and Modern Science and Its Ideology

Comparative Principle

Aspects of the relation between state, dominant nation, cultural diversity and modern science in terms of understandings of cultural difference and of the ideology of modern science.

On Cultural Diversity

Both Portugal and England are now culturally diverse societies, although to a different extent. Both countries acknowledge such diversity at the level of political discourse and, up to a point, at the policy level. This tends to be more the case in England than in Portugal. Both societies face problems involving racism and discrimination. Politics of recognition are operating in both countries, as various groups attempt to find means of attachment. Again, such politics are more visible in England than in Portugal.

The culturally diverse nature of English society has a longer history than that of Portugal. Particularly since the 1960s, issues of cultural and national identity have been on the political agenda in this country. Contemporary debate is marked by a past of struggle for recognition and fight against assimilation, integration and racism. Cultural difference has been constructed within a context of various forms of nationalism defined by the several UK autochthonous groups, by cultural demands from external non-dominant groups, and by needs of state cohesion generally expressed through revivals of Britishness.

In Portugal, debates on cultural difference have a more recent history. They are mainly related to the settlement of external groups in the country after 1975. Portuguese national and cultural identities have been perceived in a direct equivalence since Portugal was quite often understood as the closest example to the nation-state model. In a short period of time (from the late 1970s until now), Portugal was faced with profound change which implied the development of new understandings of cultural difference. Ambiguity tends thus to be a characteristic of the means to understand and deal with cultural diversity. For that, the country is finding its own path along with making use of socio-economic models of other countries, particularly those of its EU counterparts.

On Understandings of Modern Science

Portugal and England give a great deal of importance to scientific and technological development. Both countries understand modern science as a major means for progress/sustainable development. Both countries also tend to sustain the ideology of modern science in terms of its superior value as a means of knowledge production, and as a metanarrative on the natural world.

Such an understanding of modern science seems to have been common to both countries for a long time. However, for a long time, it was much stronger in England than in Portugal. The latter was governed by a conservative and anti-progressive elite, which found in scientific development a means of empowerment of the working class. Emphasis on scientific development in Portugal is mainly a result of recent needs to develop modern science in the country. In England, the emphasis can be seen as resulting from an intention to continue at the cutting edge of scientific and technological development. Both countries sense the need to promote positive images of modern science so as to sustain its development. Consequently, concern with scientific literacy is a characteristic of both Portuguese and English politicians.

Portugal/England, Cultural Diversity and State Education

Comparative Principle

Aspects of state education regarding dominant nation and cultural diversity.

Both the Portuguese and the English education systems are mainly designed for the dominant nation, even if this seems clearer in the Portuguese case. One finds educational discourse regarding cultural diversity in both countries, but one does not find a great deal of effective policy. This tends to be particularly the case in Portugal as cultural diversity has a very recent history in the educational system.

In both countries one finds an understanding of education and cultural diversity mostly centred on deficit and remedial models. The educational system is mainly understood in terms of majority and non-dominant groups. One does not quite find an understanding of education for a culturally diverse society. Consequently, great responsibility is put on teachers to develop practice according to the characteristics of their students. Intercultural education is present mostly at the level of educational discourse but one does not find any statutory elements regarding it in either of the two educational systems. These aspects are valid for education in general and they are also valid for science education.

Comparative Principle

Presence and characteristics of the ideology of modern science in the science education curriculum, particularly regarding understandings of cultural difference.

The findings of Chapters 6 and 7 indicate the presence of the ideology of modern science in Portuguese and English science education. In the two countries, the subject is mainly oriented by social and economic aims based on the need to produce both a scientific community and a population confident in modern science, so as to guarantee economic development. In both countries positive images of modern science, quite often encased in the latter's ideology, can be found in science education policy and discourse. Moreover, the ideology of modern science tends to be at the basis of science education aims. The findings also indicate the role of this ideology in the possible promotion and transmission of understandings of cultural difference, which implicitly attribute superior value to 'Western' cultural elements, values and ways of life, through science curricula.

In terms of orientation, content and methodological suggestions, similar elements were found in the curriculum of both countries as regards the presence and transmission of models of modern science that tend to:

1. present it as the metanarrative about the natural world;
2. present scientific methodology as the means of reasoning;
3. support notions of social and economic progress which can endure and promote the idea of 'Western' superiority in terms of cultural elements, values and ways of life.

Modern science is often presented in both curricula as the provider of answers. The latter tend to be considered as the absolute truth regarding understandings of the natural world. This characteristic is common to both curricula and it is almost identically expressed. In terms of presentation of scientific methodology as the means of reasoning, one finds a common pattern in both curricula, although to a certain extent, more comprehensively developed in the English one. A defined scientific method is considered a very important element of science education. The English curriculum devotes an entire study unit to it – *Scientific Enquiry*, whose content crosses all other units. In the Portuguese curriculum, great attention is also given to scientific methodology in a cross-science-subject way. However, no explicit reference to *a* scientific method was found.

Within the study of the scientific methodology in both curricula, great emphasis is placed on the students' development of particular skills of which classification appears as a fundamental one. Moreover, it is many times presented as the means to understand diversity in general. Within such a framework, 'Western' means of reasoning may be implicitly understood as the means to understand diversity.

Both curricula present modern science as a main contributor to sustainable development. Both consider the importance of reflecting on the impact of scientific and technological development in areas such as the environment, health, and industry. However, neither curriculum seems to involve particular discussions on such an impact concerning issues of cultural diversity. Scientific and technological impact tends to be considered in general terms. Hardly any discussions are considered which relate to world divisions of resources, and economic and political power. The discussion is very often focused on the impact of scientific and technological development in 'Western' societies within a context of culture and 'race' blindness.

Both curricula tend to take a culturally-blind approach. All students seem to be considered within a framework of similarity no matter what their cultural and ethnic background is; in other words, cultural and ethnic backgrounds are seen as unimportant in the process of learning science. No specific references are made to intercultural education or to intercultural science education. The study of modern science is considered by both curricula mainly within a framework that extends beyond of culture.

The similarities found between the two curricula are consistent through the various Key Stages in that they involve not only content and suggested methodologies for teaching and learning, but most importantly, curriculum orientation. The results found for the English and Portuguese science education curricula are in agreement with both states' comprehension of modern science, cultural diversity and education.

Several similarities were found regarding the Portuguese and English understandings of cultural diversity, modern science, and state education. These similarities could be seen reflected in the aims and design of science education in both countries. Particularly, they were reflected in the characteristics of the compulsory curricula of physics, chemistry and biology. Nonetheless, there are enough significant differences between Portuguese and English societies to produce questions on the nature of the similarities found. Attempts to respond to such questions are the object of the next section: are these true similarities or disguised differences?

8.3 True Similarities - Disguised Differences

Section 8.2 presented a general comparison between the findings of Chapters 6 and 7. This section discusses the results of such a comparison focusing on curriculum analysis.

On the Nature of the Similarities

The comparison indicated how similarly both the Portuguese and the English science curricula seem to consider and promote images of modern science which are directly related to its ideology, as defined in this thesis. Consequently, and considering the discussions in Chapter 2, section 2.4, both curricula may be contributing to the promotion and transmission of understandings of cultural difference that favour dominant groups in the Portuguese and English societies. The presence of the ideology of modern science in the science curriculum of both countries may be contributing to the maintenance of notions of 'Western' cultural supremacy. Non-'Western' students living in these countries may be exposed to the need to re-evaluate their cultures in ways that may imply processes of assimilation. This may be particularly the case regarding understandings of modern science as the metanarrative on the natural world, and scientific means of reasoning as the means of reasoning. This section will argue however that, although the similarity found between the findings is real, it hides and relies upon an apparent similarity between the two countries. The results found are similar but they have different meanings in and for each country.

Contemporary Portugal and England share many common characteristics of a varied nature. Both countries are members of the European Union. Both are democracies, nationally and internationally perceived as Western European societies. Portugal and England were once imperialistic nations and thus, both share a past of colonialism and a present of migration into their territories. Nevertheless, these contemporary similarities do not share the same causes. They are consequences of different processes. They can be seen as the result of a forced process of approaching between the two societies, developed by the Portuguese one in relation to a common model of 'Western' long appropriated by the English society. The next paragraphs will discuss elements of such a process in terms of state understandings of modern science, education, particularly science education, and cultural diversity so as to further discuss the nature of the findings which resulted from the comparison.

Portuguese and English Societies – From Different to Apparently Similar

Unlike English democracy and capitalistic economic orientation, the Portuguese counterparts are, in effect, a result of the 1980s. The dictatorial regime which held power in Portugal until 1974 not only had a fascist orientation, but it also did not promote economic development. European Union membership was the means to politically and economically recover a country which was at the verge of extreme isolation and economic decadence. However, it produced the appropriation of values, and of societal and social models of organisation defined by dominant countries of the EU, generally designated as Western European.

In practical terms, this involved effective political change in order to implement an economic and social developing pattern similar to that of other EU countries. In terms of modern science, it implied the development of a scientific policy, absent in the country until as late the 1980s. In educational terms, it promoted reform in order to approximate the structure and orientation of the educational system to that of other Western European countries, considered as further developed. Regarding issues of cultural diversity, it involved changes in identity understandings and the appropriation of external models, such as that of intercultural education, for dealing with cultural diversity.

The Case of Modern Science

During the 1980s and subsequent political changes the prevailing Portuguese discourses on modern science mostly dealt with sustainable development. Considering particularly issues of modern science and science education, such discourses presented the former as a basic means for economic improvement and for economic and political expansion of the country. To a certain degree, these discourses were similar to those put forward in England, in the 1960s, by people like C. P. Snow, and which portrayed scientific development as one basic means to combat economic decline.

As in England of those days, so in Portugal in the 1980s, such a discourse can be seen in a direct relation to a shift of power between different groups. The ideology behind the stress on the need to develop Portuguese scientific institutions was also involved in a process of removal of power from the humanities' elite. The head of the government that created the Ministry for Science and Technology was an engineer and the designated Minister for this Ministry was a physicist. This was the situation until March 2002.

This transfer of power led to the promotion of specific understandings of modern science and of its importance in societal terms. The 1990s were characterised by an emphasis on scientific literacy and by the promotion of positive images of modern science. The development of the national programme *Ciência Viva* (Living Science – discussed in Chapter 6) defined the key aim of making modern science more accessible to the average individual. Scientific literacy was also emphasised in England in this period. In both countries this emphasis had similar reflections in science education. However, the reasons behind it were once again different in the two cases.

The 1990s Portuguese state faced the need to develop modern science and at the same time the need to convince a generally scientifically illiterate population of its great importance to the country's economic outgrowth. Along with that, it had to persuade those who were already sceptical about the implications of scientific development of the need to pursue it in the country. In reality, the Portuguese population, from 1974 onwards, became too rapidly exposed to the endless positive and negative outcomes of and questions posed by scientific and technological development, with little time for reflection upon them. In England, on the other hand, scientific development had been setting questions to the population for a longer time. The 1990s promotion of scientific literacy and positive images of modern science in this country can be seen as a result of the UK state's need to sustain support for scientific and technological development. This is the case again with the initiative *2001-2002 Science Year*. Contemporary state understandings of modern science in both Portugal and England have thus common features and eventual general aims, although different origins and different specific objectives. Underneath them however, one can argue there lies the same ideology of modern science.

Scientific and technological evolution is seen as the. basis for sustainable development and innovation. Information technology societies are assumed to be the present and future models of social organisation, and the development of skilled populations is a central state aim. In order to legitimise this political and economic understanding of modern science, both Portugal and England seem to make use of a similar ideology on it. This ideology is not new. One can argue that it has been present in political discourse on scientific development in both countries since the nineteenth century. Those who advocated the importance of modern science in Portugal, even during the dictatorship period, tended to be supporters of such an ideology.

Changes occurred regarding the 'form' of the ideology but this seems not to be the case of its nature. Challenges to scientific development have produced new means of expression for it. In English discourse this seems to have been the case. Modern science tends to continue to be presented within a 'beyond ideology' framework, although concern with particular results of scientific development is also considered. This is often the case in Portugal, too. However, as scientific development is a recent characteristic of the country, most of the reactionary and cautious discourse on modern science can be understood as a result of internal and external effects of globalisation. In other words, changes in discourse have also been very much related to the importation of positive and negative outcomes of scientific and technological development. Consequently, means of dealing and understanding the ideology of modern science in both countries tend to have specific characteristics according to their different needs.

Supported by the same ideology of modern science and with Portugal forced to redefine its educational system according to external pressure and internal needs, it is not surprising that science education in the two countries shares certain characteristics. Particularly those discussed and which are of orientation, content, and suggested teaching and learning methodology as far as images and understandings of modern science are concerned. These are mainly the result of similar political discourse in science education in particular, and in education in general. Moreover, these can also be seen as the result of recent curricular design. Nonetheless, they are generally supported by different specific educational aims and they highlight the tendency of the two societies to converge in terms of values and ways of life.

The Case of State Education

The Portuguese and English educational systems differ in many respects, although contemporarily one finds certain similar tendencies. These mainly result from contemporary change in both educational systems. Internal change in England, and external and internal pressure for the transformation of the Portuguese society in Portugal demanded such change.

The Portuguese educational system has a long tradition of centralisation unlike the English one. It is still oriented by a statutory national curriculum, which is common to all schools in the country. This curriculum involves general aims and guidelines, content and suggested teaching and learning methodology. Although reform occurred in Portuguese education during the last decades, only now are issues of curriculum decentralising being publicly discussed for eventual future implementation. The proposed decentralisation does not imply the end of a national curriculum. It mainly involves flexibility of curriculum management.

Discourses on educational standardisation have also been occurring. For the first time in the academic year of 2000-2001, young Portuguese children were examined and school results were published. However, original concern with issues of literacy and numeracy was directly related to the high level of illiteracy among the Portuguese population. This is not exactly the case in England, as concern with literacy and numeracy derives mainly from the belief that literate and numerate individuals are easier to prepare for the labour market.

In England, education reform has been continuous in the last decades. Significant movements occurred towards curriculum centralisation with the introduction of a national curriculum. Educational standardisation, as a means to achieve excellence, was developed. Every year, English children are subjected to final examinations, whose results are nationally known via newspaper publication. Although the National Curriculum involves flexibility of management, standardisation is implying a common educational framework for all children in English state schools.

To a certain extent, the Portuguese and the English educational systems are increasingly similar in terms of the issues considered in the paragraphs above. However, and once again, the reasons behind such a *similarity of outcome* are different in the two cases. The Portuguese educational system is ruled by a 1986 Education Act that is fundamentally the result of the acknowledgement of particular educational needs which were in a direct relation to the endorsement of political changes. This Act reflected the urgency of developing mass education, of promoting secondary education, and of improving particular areas of higher education. It reflected the urge for democratising and politicising the Portuguese population. It reflected political change and desired economic and social changes within a framework of democracy, capitalism and membership of the European

Union. Education was understood as a very important means of individual and state empowering. Although changes have occurred, the 1986 Education Act is still statutory.

Education decentralisation is not a new issue in Portugal, as the Portuguese educational system was often seen by many in the country as an over-centralising one. Contemporary issues of decentralisation tend to be related to school empowering and autonomy, for example, as an apparent means to provide better educational opportunities for minority groups.

Contrary to the Portuguese case, education in England has traditionally been decentralised. Autonomy was for a long time a characteristic of schools and educational authorities. The centralisation of English education is a result of the 1980s with the introduction of the 1988 Education Act. As in Portugal, the late 1980s were years of educational reform in England. However, contrary to Portugal, such a reform has been seen as implying a disempowerment of schools and local education authorities, a differentiation in educational distribution in terms of the public and private sector, and the negation of individual initiatives regarding specific situations and regional characteristics. For example, while proposals for curriculum decentralisation in Portugal consider the importance of individual initiatives regarding better education for minority groups, centralising in English education tends to imply the negation of such initiatives. Moreover, while change in Portuguese education involved an opening of the country to the outside world focusing on the development of an European identity, a great deal of change in English education seems to be directly related to a revival of Englishness.

The Case of Science Education

Concerns with the country's identity and with the development of skilled individuals can be seen as orienting educational development in England. Much of contemporary state discourse focuses on education for employability. Such a discourse is often colour and culturally blind and it tends to associate equality of opportunity with employability for all. Science education is considered a key element in such an educational framework. Skills associated with scientific methodology, particularly defined in terms of problem-solving, are often ideologically taken as life-long skills for employability in an information technology society. Within such a context, science education can be understood in England as a double-sided means for economic development. On the one hand, it can contribute to the development of future scientists and technologists; on the other hand, it can give every individual a set of skills which are seen to be of great importance in the marketplace. A practical educational result of such an understanding has been the emphasis on science education since Key Stage 1, and the strengthening of the study of scientific methodology. The latest curriculum change in science education is a good example of that as it involved the creation of the study area *Scientific Enquiry*.

The introduction of a defined scientific policy in Portugal produced a reinforcement of Portuguese science education. As in England, science education is therefore taken as a key educational element. However, differences in understandings of science education are found in the two countries. Unlike England, which has a long tradition of scientific and technological development and of the participation of scientific advice in decision-making, Portugal is still establishing such aspects. The Portuguese development and input given to science education can be understood as a means to secure a scientific community, promote scientific advice in decision-making and, most of all, create a positive attitude towards modern science that can legitimise its development in the country. Although skills related to scientific methodology in association with problem-solving are considered important, their connection to employability is not so much emphasised as in English education. English educational discourse tends to be centred on the development of skills and employability. The creation of the Department for Education and Skills is a good example of that.

The most important common point regarding state understandings of science education in both countries seems to lie in the need to persuade individuals to accept and promote scientific and technological development. In order do that, one can argue that both educational systems tend to make use of the state ideology on modern science, which is the same in both cases. Consequently, one finds in both science curricula, in terms of general orientation, content and suggested teaching and learning methodology, common understandings of the explanatory nature of scientific knowledge, of the possibilities of scientific methodology, and of the relation between modern science and societies. The stronger English emphasis on a scientific method can be seen in dependence of an understanding of skills as the basis for future education. This is an issue also considered in Portuguese education but to a lesser extent.

On the Absence of Curricular Intercultural Science Education in Portugal and England

Another similarity between Portuguese and English science education is the absence of intercultural education in curricular terms regarding orientation, content and suggested teaching and learning methodology. Both curricula seem to take a colour and culture blind approach, inherently considering the subject modern science to be beyond culture. Again, this is an apparent similarity since important differences are found regarding issues of cultural diversity and education in both countries.

English education has been in the political arena for a long time as far as issues of cultural diversity are concerned. Politics of recognition and minority demands have produced educational responses such as assimilation, integration, anti-racist education and intercultural education. These politics have been seen as the reflection of state understandings of cultural identity, 'race', nationhood and education. Issues of identity are of a very complex nature in England. They involve an English national identity, a British citizenship identity and several other national, cultural and ethnic identities. Conflicts persist between English and

British identities. The English dominant group tends to bridge the distance between the two means of identification against the culturally diverse political reality of Britishness.

Educational reform of the late 1980s was quite characterised by a revival of Englishness. In many circumstances, this was defined by attitudes of colour and cultural blindness, which were seen as contributing to the support of a new form of racism – cultural racism. New Labour governments have re-introduced the discourse on minority issues but the structure of education has remained generally the same. The notion of 'employability for all' seems to have replaced that of 'equality of opportunity'. Intrinsic to such a notion is the idea that having a job ensures a good life and place in society regardless of, for example, issues of skin colour and culture.

Employability for all can hide a colour and culture blind educational approach, which can be supportive of discrimination since it does not necessarily involve education for a multicultural society. Issues on the latter are mainly considered in citizenship education, and are many times involved in broader societal discussions. This educational structure tends to attribute different roles to different parts of education, disregarding society as a whole. In other words, education in general should provide the ability to find a job; citizenship education should provide the ability to live in the society. In reality, jobs are found in societies, which have particular understandings on them and on the people that can take them.

The late 1980s reform that was implemented in Portugal was also concerned with issues of identity. The fascist regime used colonialism as a main definer of Portuguese identity. Portugal was presented as an Atlantic nation, whose main source of pride was the colonies. The end of the colonial empire with the 1974 democratisation could have produced a strong identity crisis in the country. An important means to deal with it was the opening of the country to the European

Union. EU membership introduced a new point of identity attachment to Portuguese people even if supported by values and ways of life more than in nationalistic terms. Consequently, educational reform, which is very much related to issues of democratisation, introduced a re-framing of Portuguese national identity supported by the definition of a broad European identity. Portuguese national identity tends to be emphasised by ensuring the country a place in an important political context. In reality, what is generally at stake is the improvement of every Portuguese individual's self-esteem in terms of Portugueseness.

While English national identity was being educationally reinforced by a stressing of English values, Portuguese national identity was being re-framed within an external setting of association with Western European senses of belonging. At the same time, Portugal was changing its nature as that of a supplier of migrants to one of a receiver of migrants. At a rather fast rate the country became increasingly culturally diverse. The re-framing of Portuguese national identity was then defined within a balance of Portugueseness and universalism.

The democratisation and opening of the country allowed the introduction of educational trends such as intercultural education. In England, intercultural education can be seen as the end result of a set of means to deal educationally with cultural diversity. In Portugal, it is the first state proposal for the education of minorities within a framework of universalism. In practical terms, intercultural education did not reach the Portuguese curriculum nor, therefore, science education. It has been developed under the supervision of a specific governmental department and it has evolved mainly in an additive form. Contemporarily its development is very much perceived within the framework of curriculum management flexibility; that is, schools may develop it if they feel the need to do so. Educational discourse considers intercultural education. Educational practice is mainly colour and culture blind because the country has not yet internalised its culturally diverse nature.

In England, intercultural education also found important difficulties in curricular terms. A great deal of intercultural practice is mainly dependent upon school and teacher initiative. At the governmental level, intercultural education support is given to school and teacher initiatives. This is the case for the Ethnic Minority Achievement Grant. The absence of intercultural education in English curricular science education can be seen in a direct relation to the understanding of the intercultural trend in the country. Intercultural approaches are mainly to be taken at the school and classroom levels. The political support seems to be expressed in individual ways of dealing with cultural diversity in the educational system but not necessarily in the society. The outcome of the balance of political forces regarding issues of cultural diversity in England tends to continue to support the education of all within the framework of the dominant group. In Portugal, the dominant group has not yet quite acknowledged its nature as such.

The absence of intercultural education in both Portuguese and English curricular science education can also be seen by the attachment of both educational systems to understandings of modern science which take it as beyond ideology and culture. Consequently, the classroom approach to this subject may involve intercultural elements, but that is not the case with the curriculum.

The comparison between the findings of Chapters 6 and 7 pointed out a set of similarities between the two countries. They indicated the strength of the ideology of modern science in both societies and educational systems. In particular, it highlighted a set of similar characteristics between the physics, biology and chemistry curricula of both countries. However, the social, economic and political path of Portugal and England varies significantly. Portugal tended to approximate to a 'Western' model of societal and economic organisation mainly since the late 1970s. England has been one of the definers of such a model. The similarities observed can then be understood as an evidence of the process of Westernisation that Portugal has been exposed to. The practical result to each country of such similar characteristics is yet to be known.

8.4 Conclusion

In spite of the different social, economic and political reasons that influenced science education in Portugal and England, contemporarily, the general understanding of this educational subject seems to be similar in both countries. Behind its development one finds aims of an economic nature. Science education is generally politically considered by the state as an important means to promote economic development. State discourse tends to focus on two basic issues: a) the preparation of skilled individuals and eventual future scientists and technologists; and b) the maintenance of positive images of modern science that can continue to legitimise its development.

The analysis of Portuguese and English science education curricula suggest, however, that along with such aims of an economic nature are others of a social and cultural kind. The study of the presence and characteristics of the ideology of modern science in Portuguese and English science education indicates that above all this ideology seems to be a means of cultural socialisation. The ideology of modern science can legitimise the importance of developing scientific knowledge and technology. At the same time, it can take part in processes of cultural imperialism. Modern science is portrayed as *the* explanatory paradigm. Its methodology is presented as *the* means of reasoning. Its development is taken as *the* means to evolve socially and economically.

Moreover, the analysis of particular expressions of the ideology of modern science in Portuguese and English science curricula suggest that the former may not only legitimise 'Western' cultural superiority via scientific development, but it may also contribute to the general definition of the concept difference. The emphasis put on classification as the means to understand diversity in general can be seen as an example of that. This skill is not developed in a vacuum. It is often directly presented within a context and as the means to deal with it. One can thus argue that implicit to it may be the promotion of an understanding of difference that cannot be set apart from processes and issues of classification.

The establishment of such an understanding of science education in the two countries can be seen by the absence of references to intercultural education regarding this subject. Modern science and consequently science education are mainly taken within a culture blind framework, which is in agreement with the economic and social aims under the development of this educational subject. Issues of cultural diversity may be considered at the classroom level, but not at the curriculum one.

Finally, regarding the particular case of Portugal, specific points may be made. The development of science education in this country is a recent one compared to that of England. So is that of education and cultural diversity. The bridging of the distance between the two countries has been a continuous process during the past two decades, while Portugal attempts to achieve social and economic patterns similar to its EU counterparts. Thus, the nature of the similarities which were found between the countries in terms of understandings of modern science, cultural difference and cultural diversity. To a certain extent, one can argue that specific differences of discourse are the result of a time-delay in scientific and educational development. However, if one takes the arguments put forward regarding the importance of science education as a means of cultural socialisation regarding 'Western' values and ways of life, one can argue that Portuguese science education may have been contributing to the 'Westernisation' of the country. Although considered a Western European country, Portuguese history produced in it different values and cultural understandings. The characteristics of contemporary science education may then be seen as a means to homogenise such values and understandings in terms of the general 'Western' paradigm.

Chapter 9

Conclusion

9.1 Introduction

This thesis attempts to contribute to the future development of science education in countries such as Portugal and England in ways which empower all individuals of those societies. It discussed the reflection in education of some of the complexities of the relation between the ideology of modern science, cultural diversity, states and nations. At the same time, it tried to contribute to the debate on the nature of intercultural science education in these two countries. This chapter presents the researcher's concluding thoughts on the study, implications for professional practice, and suggestions for further research.

9.2 Concluding Elements and Implications for Professional Practice

Re-thinking the Problem

The study of both Portuguese and English science education suggests that the images of modern science portrayed by the science curriculum in these countries are ideologically constructed within a specific understanding of modern science. They tend to present modern science as *the* explanatory paradigm on the natural world. Scientific knowledge is associated with a scientific method, which tends to be presented as *the* universal means by which to reason and obtain universal answers. At the same time, modern science is generally considered the best, if not the only way to promote sustainable development. This framework can imply the attribution of a superior value to 'Western' cultural values and ways of life.

The ideology of modern science portrays images of it which do not correspond to practical ways of knowledge production. Knowledge production generally occurs not only in a direct relation to various sources of power, related to politics, economics and warfare. It also tends to follow procedures, which do not directly relate to a well-defined scientific method. There are various forces driving the evolution of scientific knowledge, of which the search for answers about the natural world is only one. Nowadays, it is maybe even the less important. Contemporarily, most of the questions that modern science deals with are associated with practical outcomes. They are quite often directly connected to possible technological applications, much more than with philosophical issues on the nature of the natural world. For example, physics, which was traditionally the closest scientific subject to philosophical matters, has been subdivided into various derived subjects which are in a direct relation to technological demand. Nowadays, physics is studied, for example, in electroacoustics, applied physics, environmental physics, medical physics, biophysics, molecular biophysics, chemical physics, classical mechanics, fluid dynamics, kinetics, computational physics, condensed matter properties, physics of semi-conductors, superconductors, radiation physics, electronics, computer electronics, metrology, optics, quantum mechanics, nuclear physics, relativity, solid state physics, statistical physics and thermodynamics. Within the discipline of physics one can find forty-two derived subjects, which include the ones considered above, many of them with an interface with other disciplines and directly related to practical matters; e.g. medical physics or environmental physics.

One can then wonder why there seems to be a tendency to educationally present modern science in Portugal and England in ways which are not related to the reality of scientific knowledge production. This question elicits other questions, such as: is this model of science education serving particular aims? Are these state aims? Societal aims? Dominant, non-dominant group aims?

The Study's Contribution

Science Education for Socialisation in Modern Science

From the perspective of the state in Portugal and England, science education is a valuable factor within the state modern educational framework, that is: education as a means ~~for~~ economic development, socialisation and individual evolution. The X study discussed elements on states' use, promotion and understanding of science education within this framework. Such analytical discussions indicated an intricate relation between the following two elements of the framework: economic development and socialisation. Both in Portugal and England, state needs were detected at the heart of this relation, whose aim tends to be to persuade individuals of the basic value of modern science.

In both educational and modern science discourses, the following inner assumption was quite often detected: if economic development is to occur, scientific and technological development must take place, and for that, society must accept and believe in the basic value of modern science. In other words, societal legitimisation of the value of modern science is perceived as a key element for the evolution of the latter, which is taken as indispensable for economic growth. A very important role can then be attributed to science education, namely that of promoting positive images of modern science; to put it differently, that of contributing to socialising individuals in the metanarrative of modern science. A simple example of that can be seen in the emphasis put by states on programmes for the promotion of scientific literacy. This is the case in Portugal with the national programme *Ciência Viva* (*Living Science*, considered in Chapter 6) and in England with initiatives such as *2001-2002 Science Year*. At the heart of both programmes mainly lies the diffusion of positive images of modern science.

One can thus argue that a possible reason behind the gap between 'real' modern science and modern science as it is presented in schools lies in state needs to promote images of the former, which may continuously legitimise the development of scientific and technological knowledge. If this is the case, science education can be seen as serving, above all, the economic needs of the state. Possible implications of this in and for culturally diverse societies can be of importance.

Cultural Imperialism and Westernisation – More Questions

As the studies in Portugal and England suggested, such a means of developing science education seems to involve implicit elements of cultural imperialism. These can be seen as attributing a superior value to 'Western' cultural values and ways of life. Within such a framework, at the same time that science education is supporting scientific development, it may be socialising people in ways that can contribute to legitimising 'Western' cultural superiority. This may be so because it may be contributing to the ideological, social and economic promotion of concepts of difference that can give privilege to 'Western' values, culture and ways of life.

Another question can be posed at this point. Being modern science, as considered in this thesis, a European conceptual product, mainly associated with 'Western' values and European cultural elements, how far is modern science's potentially cultural imperialistic nature related to the ideology of modern science? To put it differently, are there any inner cultural imperialistic elements in modern science itself which reach beyond its ideology? If this is the case, then several questions arise regarding science education. The main question relates to the possibility or impossibility of teaching a totally neutral understanding and language of the natural world.

It is not possible, at this point and with only the research in this thesis, to provide answers to such complex questions. However, elements for further discussion can be put forward so as to contribute to future analyses and research on the nature of science education and to that of intercultural science education. One of those elements concerns the practical value of teaching science education to all individuals.

The Practical Value of Science Education – Importance and Risks

Scientific means of reasoning have been very important in the social and economic conceptualisation and organisation of Western European societies. It is plausible to argue that an individual who can operate to a greater or lesser extent with such means of reasoning is empowered in relation to one who can not. The first individual can better understand the way these societies are constructed, hence better operate and participate in them. Scientific literacy, in this perspective, can be an important element in each individual's life, regardless of his/her cultural background.

One can consider that what is at stake is a practical understanding of the importance of scientific methodology. Yet, some risk may lie in possible attachments between such a methodology and cultural imperialism. There is not yet enough research to know how far learning scientific methodology can imply a denial of other means of understanding characteristic of different cultural groups, even if the latter make use of the same skills. At the same time, there is not yet enough research to know how effective understanding the ideological elements eventually associated with scientific methodology may be in preventing processes of cultural imperialism, which may occur while studying such a methodology. In fact, it is not at this stage possible to know whether scientific methodology can be taught separately from the ideology of modern science.

In both Portugal and England, the ideology of modern science seems to be present within the teaching of scientific methodology. For example, teaching skills such as classification are not generally considered in a vacuum. Moreover, such a skill tends to be studied as the means to understand diversity. The question thus is whether one can neutrally teach how to classify? If so, is such teaching still within the realm of scientific methodology or is it already beyond it?

A similar remark can be made in relation to scientific knowledge. Scientific knowledge is again not taught in a vacuum. The concepts tend to be encased in a particular understanding of the world. Is it then possible to teach just the concepts neutrally, or are we then beyond the limits of modern science?

If one considers that 'Western' cultural elements and values may inherently be part of modern science then one has to consider their presence in science education. If this is the case, science education is inherently a socialising element, which can contribute to the cultural socialisation of all individuals regardless of their cultural backgrounds. This socialisation is thus mainly defined in terms of 'Western' understandings of the natural world and 'Western' influenced ways of reasoning. Is such a socialisation necessarily a bad thing?

On the one hand, if this socialisation indeed occurs, it can conflict with cultural elements of a 'non-Western' nature. Individuals from cultural backgrounds other than 'Western' may be subjected to a forced process of acculturation. On the other hand, however, it has already been considered that understanding the nature of modern science and knowing how to operate with scientific knowledge and methodology can be a means of individual empowerment. How might then science education be conceptualised? The next paragraphs present a discussion on a tentative framework for science education. The latter is supported by the knowledge that resulted from the study and taking into account the study's limitations.

Elements of a Framework for Science Education

The discussion presented in the paragraphs above seems to lead to a conundrum. On the one hand, science education presents itself as a basic element to ensure the continuing development of modern science. As the latter constitutes an inner part of contemporary societies, it seems unthinkable to disregard the importance of science education at the level of the individual. From him/her demands are made regarding modern science. States ask individuals to support scientific and technological development. Societies require individuals who can decide on the nature of such scientific development. Individuals need to know how to operate in increasingly scientific and technological environments. On the other hand, however, as the study pointed out, science education may contribute to cultural imperialism and westernisation.

Without further research, one can only make use of pragmatism while recognising the limits of the proposals that one may present. Consequently, what can be argued at this stage is that science education should not only include teaching scientific knowledge and its relation to societies in general terms. It should also include teaching about the nature of modern science, particularly focusing on the ideology of modern science.

As has been considered in this thesis, understanding modern science cannot fully occur if one does not understand the discourse on it that developed alongside the evolution of scientific knowledge. The nature of contemporary modern science is inherently related to its ideology. Teaching scientific knowledge without taking into account the political, economic, social and, above all, ideological aspects of the concept of modern science is depriving each individual of understanding the basis of the relation between modern science and societies. Moreover, it is depriving him/her of understanding the possibilities for cultural imperialism and westernisation that may be associated with science education.

One can then propose that modern science should not be presented in Portuguese and English science education in a detached way from social, economic and political aspects of societies. The following elements should be basic to science education in Portugal and England:

- teaching and learning of scientific knowledge;
- teaching and learning about modern science, particularly focusing on the nature of scientific knowledge and on that of its production, and on their relation to the ideology of modern science.

The curriculum of science education should then include a de-construction of the ideology of modern science along with a clarification of the possibilities of this ideology for cultural imperialism. This could allow a better comprehension of the nature of modern science and of the relationship between the latter and societies.

It could also be important for the development of a better understanding of the nature of scientific knowledge and of its production. It could give students the ability to better comprehend different systems of knowledge and the possible power relations between discourses on them.

In this context, within curricular science education, alongside scientific knowledge, the following should also be included:

- elements of philosophy of science specifically regarding the nature of systems of knowledge and that of knowledge production. Modern science should be considered and discussed as a system of knowledge with specific means of knowledge production;
- elements of sociology of science, particularly those on the creation of political, economic, and ideological discourses on modern science, as well as others on the power relations involved and associated with the production of scientific knowledge;
- the relationship between scientific knowledge, technology and individuals and societies specifically considering aspects such as cultural diversity and the nature of cultural difference.

Involving the elements above, the curriculum of science education may be better able to contribute to the preparation of scientifically literate citizens who may better understand, and thus operate in, culturally diverse societies defined by scientific and technological knowledge. At the same time, it may contribute to minimising the role of science education in specific constructions of cultural difference, which tend to privilege 'Western' groups. At issue then is teaching about modern science, its nature, and its relationship with economy, political power and culture. In culturally diverse societies, such as the Portuguese and the English, which are the primary focus of this thesis, science education may then be more able to contribute to better understandings of cultural difference.

This framework is for science education in Portugal and England. Can it constitute the basis of intercultural science education in these two countries? Moreover, is it legitimate to think about science education and intercultural science education separately?

The Nature of Intercultural Science Education Revisited

The tentative framework for science education presented above was put together taking into account the nature of Portuguese and English societies, as well as the results of the study. Would this framework be one of intercultural science education for Portugal and England?

The proposal for teaching about modern science, particularly including a de-construction of its ideology and a clarification of the possibilities for cultural imperialism constitutes a suggestion within the context of education on modern science. In fact, it is this, which in practical and real terms, is the issue in contemporary science education in both Portugal and England. Whether such a model is within the framework of intercultural science education or not is directly dependent on the approach taken to the nature of the latter.

From a universalistic point of view, it could constitute the basis for a model for intercultural science education as universalists do not accept the distinction between science and modern science. However, they implicitly support the supremacy of modern science over any other forms of knowledge of the natural world. In this sense then, intercultural science education would be inherently embodied in contradictory elements. It could be implicitly attributing superior value to 'Western' culture, values and ways of life, while attempting to contribute to a reduction of cultural imperialism.

From a robust multiculturalistic point of view, intercultural science education involves a broader notion of science, which is beyond that of modern science. The production of scientific knowledge is not just the result of the Scientific

Revolution. It precedes it. The seventeenth century synthesis of scientific knowledge and the nineteenth century ideological synthesis on understandings of knowledge produced modern science, as has been considered in this thesis. At the same time, a superior value was generally attributed to this means of knowledge production and understanding of the natural world. There have always been other means of understanding the natural world and of producing knowledge in relation to it. Broader criteria can be established so as to define a broad and more inclusive concept of 'science'. This involves modern science and other means of reasoning about the natural world, without any relations of subservience between them. Problems can then arise concerning the kind of criteria that define this concept of science and the societal factors affecting it. Again, one could question the neutrality of such a subject. In these circumstances, intercultural science education would then be a school subject in this science, and consequently, the framework presented above would not be one of intercultural science education.

There have been attempts to define such a subject involving for example knowledge of the natural world produced by Native American Indians. However, there has been a tendency to establish relations of subservience between this knowledge and modern science, as the latter is politically far more powerful. The important question however, is whether or not one should teach intercultural science education as considered in this robust multiculturalistic perspective in culturally diverse societies such as those of Portugal and England.

Again, answers to this question are limited by the lack of existing research in the field. One can only speculate on possibilities. In order to do that, one must go back to the value of science education in those countries.

Science education, as it is developed in Portugal and England, seems to serve mainly the aims of the state. In order to do so, it focuses only on modern science. A robust multiculturalistic framework for science education cannot thus naturally be considered by state mainstream Portuguese and English education. At the same time, would this framework benefit Portuguese and English individuals?

On the one hand, it would allow the teaching of other means of understanding the natural world and of reasoning about it. It could remove superiority from modern science and could contribute to diminish cultural imperialism. On the other hand, it could also deny individuals the ability to understand the reality of contemporary societies, which is to a large extent defined by scientific knowledge and technology. It is difficult to argue whether in societies such as the Portuguese and English ones this model of intercultural science education would be a means of individual empowerment or the opposite. Moreover, it is even more difficult to define which concept of science should be involved.

The debate on intercultural science education has been mainly oriented by two academic positions: universalism and robust multiculturalism. These are based in two opposite understandings of the nature of modern science: universalism and relativism. Implicit in the debate, there seems to be the belief in the possibility of defining a general framework for intercultural science education. The discussions held in this thesis pointed out the difficulties, if not the impossibility, of such an endeavour.

On the one hand, education, and thus science education, is context and culture related. On the other hand, modern science has been globalised. Regardless of each individual's position towards modern science, each of us is faced with its constant presence in our individual and collective lives. One cannot thus, disregard teaching and learning of modern science. Intercultural science education cannot disregard teaching and learning of modern science. How far intercultural science education includes various concepts of science, and with which associated definitions and discourses, is quite possibly directly dependent of the context in which teaching and learning takes place. If one does not consider different forms of intercultural science education, one may be falling into the trap of proposing a metanarrative for intercultural science education which will be only apparently inclusive. This is not to say however, that all frameworks are valid for intercultural science education. Whatever the model it should not disregard the nature of modern science and discourses on knowledge and knowledge production.

The debate between universalists and robust multiculturalists is a polarised one. In spite of taking a relativistic position in relation to modern science, robust multiculturalists still propose one framework for intercultural science education. Both universalists and robust multiculturalists focus only in one variable to define such a framework: the nature of modern science. This researcher believes that in the definition of intercultural science education other variables should also be taken into account. One of those is that of the nature of cultural diversity and the associated understandings of cultural difference. The definition of other variables may necessarily be related to the context in which teaching and learning takes place. A common framework for intercultural science education in Portugal, England and Australia, for example, may have several different and important consequences in each of the countries.

The framework presented in this thesis constitutes one possible guiding structure for the development of education in modern science, in two specific countries, that may contribute for a better preparation of all citizens of those countries, to live and work in two specific culturally diverse and scientific societies. It can be seen as a proposal for intercultural science education in Portugal and England within a broad concept of intercultural science education that has in its basis several variables other than the nature of modern science. For this researcher this concept can not be dissociated from that of science education. Being science education defined as well by many different approaches and possibilities. Nevertheless, further research is needed to define such variables and in fact, to better understand the nature of science education in culturally diverse societies. +

[illegible] ?

Implications for Professional Practice

This thesis highlighted the presence of the ideology of modern science in Portuguese and English science education. It also discussed possible consequences of this for the promotion of cultural imperialism and westernisation through this school subject. This has important implications for professional practice in these two countries. With the research in this thesis one cannot make specific and detailed proposals for professional practice. One can only present general ideas. These will be the object of the next paragraphs focusing on teacher training.

The study discussed how the ideology of modern science is embedded in the science curricula. Quite often, educational professionals embrace the curricula in a prescriptive way. This is particularly so in centralised educational systems. It is possible to consider that this may be the case for science teachers in both Portugal and England. It is then plausible to argue that if they are not previously aware of the implications for cultural imperialism and westernisation of the ideology of modern science, science teachers will implicitly, and perhaps even explicitly, transmit it to their students.

Pre and in-service teacher training in science education in Portugal and England should not disregard issues on the ideology of modern science. This means that teacher education in these countries should include studying elements of philosophy and sociology of science, particularly focusing on the ideology of modern science. Moreover, training should also be given in the field of didactics of philosophy and sociology of science. It is not enough for science teachers to be aware of the presence of the ideology of modern science in the curriculum and of the implications of that. Science teachers should also learn how to teach about the nature of modern science and about the ideology of modern science to their students. In order to do so, they cannot only be educated in philosophy and sociology of science. They should also learn how to teach elements of the latter to their students, and how to discuss the nature of modern science with them.

However, if de-constructions of the ideology of modern science are to be developed in ways that promote a better understanding of cultural diversity, science teachers' education and training cannot disregard as well, issues of cultural difference and interculturalism. Science teachers have to be prepared to understand their subject in a close relation to all aspects of society, in particular to that of multiculturalism. This means that the study and discussion of the nature of intercultural science education, as well as that of possible frameworks for the latter, should also be an inner part of teacher training in science.

The suggestions presented above demand an understanding of science education which is beyond that of the transmission of scientific knowledge and methodology. They consider it as a means to effect such a transmission, but also as a way of transmitting how scientific knowledge is produced; how knowledge production is understood; and how modern science and societies relate at the political, economic and cultural level. Within this understanding, the cultural nature of modern science is acknowledged, and thus intercultural science education is not considered a trend in science education. It is at the latter's inner core. Consequently, intercultural science education will also be at the inner core of education and training for science teachers.

The paragraphs above presented some general ideas for science teachers' education and training which are directly related to the framework for science education proposed in this chapter. The future development of these ideas and the presentation of others demand further research. The next section will discuss suggestions for such research. In order to so, it will start by discussing the strengths and limitations of this study.

9.3 The Way Forward

Strengths and Limitations of the Study

As any other study, this particular one is limited by its nature. At the inner core of all studies lie a set of choices which limit their results. From all the choices made for this specific study that on its conceptual nature is of fundamental importance. From it resulted the study's main strengths and also its main weaknesses.

which's it?

There are very few, if any, studies on the nature of the relation between the ideology of modern science, cultural diversity and science education. With regard to intercultural science education, most of the research developed so far, particularly in Portugal and England, has focused on educational practice. This is of basic importance. However, educational practice cannot evolve if educational theory does not develop. There seems to be a gap in terms of a conceptual discussion on the nature of modern science, its ideology and culturally diverse societies, and how this may contribute to the development of intercultural science education. This study tried to contribute to this field of research, and it tried to set new problems and questions. It constitutes an original attempt to systematise knowledge in the fields of philosophy of knowledge, cultural difference and science education in culturally diverse contexts. This innovative character of the study constitutes one of its main strengths. Yet, and at the same time, it is also in the basis of important limitations.

Developing research in a new field involves taking serious risks. The first, and most important of all, is that of attempting to draw conclusions from a very limited body of knowledge and research. The results of a study like this are necessarily of a tentative nature. Their value relies however, on the fact that they constitute primary results that will enable future research, and consequently, the development of more and detailed knowledge in the new field.

Conceptual studies are increasingly valuable if they are developed along with empirical ones. The latter can be of fundamental importance in cementing the results of the former. In fact, empirical studies can contribute to reducing the tentative nature of the results of the conceptual ones. The author recognises the importance of empirical evidence for studies of this type. Nevertheless, a thesis is limited in scope and decisions have to be taken as to the balance between theory and data. These decisions will always be difficult, and the author considered it important to carry out conceptual research which could have implications both for practice and empirical research.

The study will only have practical value if it moves beyond its initial attempts to systematise a new body of knowledge. In order to do so, it must open new research problems and propose other forms of analysis different from those used in the thesis. The next subsection aims to contribute to that by suggesting a framework for further research.

Suggestions for Further Research

In order to better inform educational practice in science in culturally diverse societies, such as those of Portugal and England, deeper knowledge than that provided by this research is needed. As a contribution to the development of such knowledge, the author will present the basis of a possible framework for future research. This framework is supported by several main research problems. For each of those, the author will consider possible research questions and preliminary methodological suggestions. It is important to note however, that some of the problems are at the interface between various disciplines which are not within the field of expertise of the author. Consequently, she will present her suggestions as preliminary ones, which demand further thought in the fields of the disciplines involved.

Research Problem 1

The following question summarises this research problem:

Is it possible to separate a body of knowledge from a discourse on it?

This is a central problem in the field of philosophy of knowledge. Solutions to this problem have important implications for the development of the research initiated by this thesis. This is so as the study focuses on the ideology of modern science. Better understandings of the relationship between modern science and its ideology can have important consequences for the development of further research within the framework of analysis considered in the thesis, as well as for more general research in science education and intercultural science education.

In educational terms, the problem can be expressed as follows:

Is it possible to teach a body of knowledge in a completely separate way from a discourse on it?

In terms of science education, the problem becomes:

Is it possible to teach modern science in a completely separate way from its ideology?

Or more specifically:

Can scientific methodology be taught separately from the ideology of modern science?

Is it possible to teach just scientific concepts, neutrally, or are we then beyond the limits of modern science?

The author is not an expert in philosophy of knowledge. Moreover, the questions above represent broad and complex fields of analysis which demand a great deal of research. The author will modestly attempt to contribute to such research by presenting two possible research approaches in a rather simplistic form. The aim is one of indicating ways of looking at the problem. Concrete proposals within the approaches presented would need knowledge and study which is beyond the scope of the thesis.

Suggestion 1: An 'Archaeology' of Modern Science

Michel Foucault proposed a framework of analysis within what he called 'the archaeology of knowledge'. With this framework he attempted to better understand the nature of knowledge and its relation to sciences and discourses. It would be an important intellectual exercise to use elements of Foucault's means of analysis, and in fact, to move beyond his own object of analysis - specific sciences, by applying such analytical elements to the concept of modern science and to its relation with the ideology of modern science.

Foucault considered that

> In this *archaeological history*, what one is trying to uncover are discursive practices in so far as they give rise to a corpus of knowledge, in so far as they assume the status and role of science. To undertake a history of science at this level is not to describe the discursive formations without regard to epistemological structures; it is to show how the establishment of a science, and perhaps its transition to formalisation, have come about in a discursive formation, and in modifications of its positivity. (Foucault, 1972, p. 190)

The author is proposing in fact, paraphrasing Foucault's quotation above, 'an uncovering of the discursive practices that gave rise to the corpus of knowledge of modern science, in so far as they assumed the status and role of modern science'; 'how the establishment of modern science has come about in a discursive formation'.

Different approaches can be considered within the *archaeology of modern science.* The author will highlight three broad possibilities (defined by objects of analysis), which she believes are of particular importance. Each possibility can give rise to various studies, depending on choices of context and time. At the core of the analyses is the axiom that modern science is at least both an activity and a cultural and political discourse. The proposed objects of analysis are the following:

- the creation and development of history, sociology and philosophy of science;
- the historical evolution of positivism;
- the creation and development of environmental sciences.

These three generic themes encompass the development of understandings of modern science which include not only those on scientific methodology, but also others on issues of progress and sustainable development.

Suggestion 2: Modern Science and 'Non-Western' Understandings of It

Another possible way of looking at Research Problem 1 is by focusing on the nature of understandings of modern science in philosophical and cultural contexts other than 'Western' ones. Being modern science and its ideology (as they are considered in this thesis) European by nature, studies of understandings of both modern science and scientific knowledge production in contexts other than 'Western' are important.

Many 'non-Western' contexts have a practical approach towards modern science. They fundamentally focus on scientific knowledge production and technological development. This is quite often the case for the Asian countries of the Pacific Rim. Moreover, their philosophical schools of thought have their own understandings of the nature of scientific knowledge and of the means for its production. Analyses in those countries of such understandings of modern science, and their relation with the reality of scientific knowledge production may provide insightful contributions to a better comprehension of the relationship between modern science and discourses on it.

Research to be developed within this field may have both a conceptual and empirical nature. It may be based on the study of 'non-Western' philosophies of knowledge. It may also be based on empirical studies held with science producers and philosophers from 'non-Western' countries, so as to better understand their comprehension of the nature of scientific knowledge, and of its relation to their own philosophical understandings of the natural world. A possible example is that of analysing the understanding of the nature of knowledge on the natural world in Confucianism, and of looking at how such understanding relates to the ways of producing and conceptualising modern science held by contemporary Chinese scientists.

Conceptual studies may as well have an historical orientation. Empirical studies however, should focus on present day analyses. Another possibility is to define empirical comparative studies involving both 'Western' and 'non-Western' science practitioners and/or philosophers. The comparison between different philosophies of knowledge, focusing on understandings of knowledge production, may also be of great interest.

Research Problem 2

This research problem is, to a great extent, related to Research Problem 1. If one accepts that modern science can be entirely separated from its ideology can one immediately assume that modern science is a culturally neutral body of knowledge? In other words,

> ~~*Being*~~ *Modern science, as considered in this thesis, being a European conceptual product, mainly associated with 'Western' values and European cultural*

elements, how far is modern science's potentially cultural imperialistic nature related to the ideology of modern science?

That is,

Are there any inner cultural imperialistic elements in modern science itself which reach beyond its ideology?

If one considers such a problem within education, one can pose the following question:

Is it possible to teach modern science without any embodiment in cultural imperialistic elements?

Once more, the author is faced with a complex and broad field of research. And again, such a research field is beyond her expertise. Nonetheless, she will try to present some broad research suggestions within the framework of philosophy of knowledge. In fact, those suggestions constitute proposals of similar approaches to those presented for Research Problem 1.

Suggestion 1: An 'Archaeology' of Scientific Concepts

Like in suggestion 1, for Research Problem 1, the use of Foucault's analytical framework is proposed. Such a framework would now be used to analyse the nature of the formation of scientific concepts. This analysis could focus on the history of specific scientific concepts, looking at their formation and evolution in time.

Suggestion 2: The Nature of Scientific Concepts in Contexts Other than 'Western'

Again, in a similar manner to suggestion 2 put forward for Research Problem 1, research in contexts other than 'Western' would be of significance for the development of a better comprehension of the nature of scientific concepts. Such research could have a comparative orientation. A comparison between the nature of scientific concepts in different cultural contexts could contribute to the understanding of the possibilities of the embodiment of 'Western' culture in them.

Again this research could have a conceptual and/or empirical approach. It could be supported in the history of scientific concepts in various contexts. It could also be supported by empirical studies developed with scientists and historians of science.

Research Problem 3

The study highlighted the attribution of superior importance to the scientific methodology in the science curricula of both Portugal and England. It also considered how a particular scientific method is presented in these curricula, and how it is expected that students learn such a method and apply it in many different contexts, both scientific and non-scientific.

Scientific methodology makes use of particular skills in specific ways. It constitutes a means of reasoning. The same skills may be used in other ways that define other means of reasoning. One can even argue that different cultural groups may have different understandings of the same skills and use them differently. For example interpretation and argumentation have different meaning within European and Asian cultures. Asian forms of argumentation are strongly based in holistic understandings of problems. European forms of argumentation tend to have a more mechanistic approach.

Considering the importance attributed to the scientific methodology in science education one can pose the following research problem:

Does learning scientific methodology necessarily imply a denial of other means of understanding characteristic of different cultural groups, even if the latter make use of the same skills?

This research problem is mainly within the field of cognitive psychology and neuroscience. It involves analysing the effects of teaching a particular means of reasoning. It involves trying to understand how reasoning choices are made, that is, which ways do individuals use to reason in different circumstances, once faced with particular problems.

Research within the field of this research problem would be necessarily empirical. One can envisage studies in which individuals from different cultural backgrounds may be exposed to a common problem and to various solutions to the latter. Such solutions may be based in different ways of approaching the problem, one of those being a scientific one. Individuals may be asked to choose preferred solutions and to justify such a choice. This is an over simplistic suggestion. The author cannot make concrete proposals in the fields of cognitive psychology and neuroscience as they are beyond her level of expertise.

Research Problem 4

This research problem is directly related to the one above, and it can be expressed by the following question:

How effective is the understanding of ideological elements eventually associated with scientific methodology in preventing processes of cultural imperialism, which may occur while studying such a methodology?

This research problem is directly related to one of the proposals of the framework for science education presented in section 9.2. Such a proposal refers to the value of de-constructing the ideology of modern science, so that individuals may be aware of cultural elements within modern science and of their potential imperialistic nature. It is very important to better know whether this constitutes or not an effective strategy, thus, the fundamental importance of this research problem.

Research within the field of the problem is of an empirical nature. A possible study can be one that looks at two groups of students who are exposed to similar science content, however, approached in two different ways. One of those ways presents such scientific knowledge and methodology without any de-construction of the ideology of modern science. The other way does completely the opposite. Each group could be exposed to the respective approach during an academic year. Analyses would be conducted on the students' understanding of the nature of scientific knowledge and its relation with societies at specific periods of time. One can consider for example, the beginning, the middle, and the end of the academic year. These analyses could be supported by questionnaires and interviews.

Research Problem 5

The educational presence of the ideology of modern science was looked in this study in the compulsory science curricula of two specific 'Western' European countries. This research problem implies an extension of such analysis, and it can be generally expressed by the following question:

How embedded in education is the ideology of modern science?

The problem involves others that can be defined by the research questions below.

1. **The ideology of modern science in science education textbooks and educational practice**

This thesis focused on the science curriculum. However, science education involves other elements. That is the case for textbooks and for educational practice. Understanding how embodied in science education is the ideology of modern science can not disregard the following research questions:

Is the ideology of modern science embedded in science textbooks?

How far is the ideology of modern science embedded in science classes?

Are science teachers transmitters of the ideology of modern science in their practice?

Answers to these questions demand both bibliographic and empirical studies. They demand studies on science textbooks. They demand studies based on observations of educational practice and interviews with science teachers and students.

2. **The ideology of modern science beyond science education**

One can only understand the extension of the embodying of the ideology of modern science in education if one looks at its eventual presence in subjects other than scientific ones. Modern science is included in the study of history and geography. It is very important then, to look at which images of modern science are being portrayed by education in these subjects. The following research questions can be formulated:

Is the ideology of modern science only present in the curriculum of science subjects or can one find it as well in curricula of subjects such as history and geography?

Is the ideology of modern science embedded in textbooks for subjects such as history and geography?

Do teachers of history and geography transmit the ideology of modern science in their practice?

As in the case of science education, in order to answer the research questions above, one can envisage the development of bibliographical studies focusing on history and geography curricula, as well as on textbooks for these disciplines. One can also envisage empirical studies based on observations of history and geography classes and in interviews with teachers and students, in order to better understand the embodying of the ideology of modern science in educational practice regarding these subjects.

3. The presence of the ideology of modern science in educational systems other than the English and the Portuguese

Is the ideology of modern science present in science education in 'non-Western' European countries?

The study looked at modern science in the particular cases of Portugal and England. However, it would be very important to look at other countries outside 'Western' Europe. It would in fact, be interesting to compare the presence of the ideology of modern science in both 'Western' and 'non-Western' educational systems. One can then envisage comparative and non-comparative studies in various countries oriented by research questions similar to those considered in 1 and 2.

4. The ideology of modern science and teacher education

Science teachers, as well as history and geography teachers, for example, can play a fundamental role in the transmission of the ideology of modern science in their educational practice. It is then important to pose the following question:

> *Are teachers (of science and other subjects) aware of the presence of the ideology of modern science in education and of their role as its transmitters?*

Studies based on observations of educational practice and on interviews with teachers can then be proposed. However, if one is to know in detail the extension of the presence of the ideology of modern science in education one cannot disregard an eventual presence of such an ideology in teacher training. One can then propose curricular analyses as well as empirical studies in teacher education, focusing on understandings of modern science and on their relation with the ideology of the latter. Similar research questions to those considered above in 1 and 2 can be posed so as to orient such studies.

Final Note

This study tried to show the level of complexity around science education in culturally diverse societies. It highlighted how teaching and learning an educational subject may have consequences other than those previously defined or expected. It tried to set new questions and new approaches to the ways of looking at science education. By presenting a possible framework for this subject for Portugal and England, as well as a framework for research that is inclusive of various fields of knowledge, the author hopes to have contributed to the development of new knowledge in science education and cultural diversity. She hopes that this and future knowledge may contribute to the development of educational practice, in countries like Portugal and England, that will be able to empower all individuals regardless of their cultural background.

Notes

Chapter 1

[1] Race is considered under inverted commas in the whole thesis so as to report to the controversial nature of the concept.

[2] A discussion of the reasons behind the choice of a curriculum analysis is developed and presented in Chapter 5.

[3] In England the National Curriculum is not compulsory in private schools.

[4] Detailed discussions on these issues are presented in further chapters of the thesis (Chapters 3, 6 and 7).

[5] Again, discussions on these issues will be put forward later on in the thesis (Chapters 4, 6 and 7).

Chapter 2

[1] For developed discussions on this issue see Bhabha (1990), Giddens (1985), Held (1995) and Hobsbawm (1990).

[2] The Germanic invasions started in the fifth century AD and their end was determined by the final Norman conquests in the 11th century.

[3] In reality these categories are a result of the USA/former USSR cold war, which has been maintained until today. They were first considered in 1949 by President Truman. (Escobar, 1995)

[4] Dual Revolution designates the French and Industrial Revolutions together.

[5] This issue will be discussed in Chapter 3.

[6] For an interesting discussion on these issues see Fuller (2000).

Chapter 3

[1] Nevertheless, English education was fundamental in later constructions of British and English identities, and moreover, in attempts to establish an equivalence between the two (Gundara, 2000a).

[2] Republicanism was forcedly introduced in Portugal by 1910.

[3] O projecto do Governo é, igualmente, um projecto de afirmação dos nossos valores culturais, da nossa vocação universalista e da afirmação da nossa identidade própria assente no respeito pelos outros e pela diversidade. Mas é também um projecto de união e de entendimento de todos os que usam a língua portuguesa como veículo de comunicação, uma aposta solidária no papel que tem que ser conquistado para a expressão da cultura portuguesa espalhada pelo Mundo e para todos os povos e países que fazem do Português a sua língua própria. (Governo, 1999)

[4] A cultura Portuguesa, marcada por um universalismo procurado e consciente e pelos múltiplos encontros civilizacionais que, ao longo dos séculos, têm permitido o acolhimento do diverso, a compreensão do outro diferente, o universal abraço do particular; é uma cultura aberta e mestiçada, enriquecida pela deambulação de um povo empenhado na procura além-fronteiras da sua dimensão integral. (...) A educação deve, pois actuar sobre o comportamento individual e contribuir decisivamente para a formação integral do ser humano, tornando-o apto a viver a sua liberdade e autonomia, capacitando-o para a dimensão plena da solidariedade e do respeito pela dignidade do outro, consciencializando-o do valor da Língua, da História Pátria e dos traços dominantes da identidade nacional. (...) Mesmo na nossa sociedade, emergem manifestações de intolerância e, em alguns casos, de violência física e psicológica exercidas sobre minorias étnicas. (...) Conscientes de que tais acções (...) necessitam de uma actuação que vise incentivar a educação cívica e contribuir para um clima de aceitação, solidariedade, tolerância e respeito pelo direito à diferença que deve envolver toda a acção educativa. (Ministro da Educação, 1991, pp.1274-5)

[5] Whenever the expression 'ideology of modern science' is used it refers to the ideology of modern science as put forward in Chapter 2, Section 2.3.

[6] Herculano tinha um ideal que tentou aplicar à vida Portuguesa; de acordo com este, o país era uma assembleia de trabalhadores rurais médios e proprietários, e industriais vivendo dos rendimentos do seu próprio trabalho (...) i.e., uma assembleia de proprietários explorando e directamente fazendo uso dos instrumentos do seu próprio trabalho. (...) Para além desta assembleia, existia um grupo ao qual Herculano não dava grande importância, um grupo de gente

que instintivamente ele desprezava. Essas pessoas eram, por um lado homens ricos, banqueiros, usurários, etc, cujo o papel real na economia do seu país ele nunca realmente entendeu; e por outro lado, trabalhadores fabris, gente desclassificada, vivendo longe da terra e da natureza, em formas lugubriosas. (...) O trabalhador rural ligado à terra confundido entre as árvores e os bois, sem meios culturais ou facilidade de movimentos não podia por em causa ou definir os interesses da sua própria classe. E, embora ele fosse a arma real de cuja qual a subsistencia da população dependia, a sua existência não era sentida. (...) [A educação] não era treino técnico para uma profissão que permitisse a um pequeno proprietário ou industrial ganhar a vida; era de facto, conhecimento desinteressado, independente de qualquer profissão, de qualquer especialidade ou tarefa de trabalho. Era simplesmente cultura geral apropriada para uma assembleia de proprietários. (Saraiva, 1945, p.82)

[7] Ninguém, cujo espírito seja dominado pelo pensamento progressista e liberal da época em que vivemos, poderá deixar de reconhecer e proclamar que a educação pública é um dos elementos mais essenciais, não somente para o desenvolvimento moral da humanidade, mas também para o constante progresso das forças produtivas da nação. Nas mãos do homem, a Ciência é, como recentemente o disse um distinto escritor, uma arma ofensiva e defensiva contra a natureza, sem a qual o homem jamais será capaz de medir, calcular e avaliar os deveres imperiosos que lhe são impostos, por forma a cumprir a sua missão de forma honrada, e por constante esforço contribuir para o desaparecimento das infinitas necessidades que o seguem desde o primeiro ao último dia da sua existência. (Ministério da Educação – Secretaria Geral, 1989)

[8] O ensino das ciências, lamento dizê-lo, é ainda extraordinariamente formalista, confunde o ensino e a aprendizagem dos processos, do porquê das coisas com a memorização papagueante das definições, umas atrás das outras, cuja principal função é seleccionar os alunos, fazer com que aqueles que pertencem a famílias com capacidade cultural mais elevada e têm melhor acesso aos bens culturais, ganhem e que os outros percam. E nomeadamente, que aqueles que têm mais aptidões técnicas, mais aptidões manuais e menos treino, desde a infância, para o formalismo, sejam definitivamente afastados da qualidade científica em troca de interesses imediatos ou por outra qualquer razão. (Gago, 1995)

[9] Huma menina deve aprender com tempo as obrigações de Filha, de Esposa e May de familias. Seu espirito he susceptivel de grande cultura e ainda mais o seu coração. Cumpre-lhe estudar os fundamentaes principios da Religião, os deveres da sociabilidade, os Factos mais memoráveis da Historia Sagrada e do seu Paiz; saber ler, escrever, contar; é a todas indispensável a quem hade prever na Economia Domestica, no ensino dos filhos, e fazer as delícias de hum consorte virtuoso. (Comissão de Instrução Pública, 1822)

[10] Tranquilizem-se pois, êsses seres femininos destituídos dos adornos da Formusura e também essas mulheres lindas que sentem já o horror do espectro da velhice: - a Ciência prepara-lhes as mais consoladoras surpresas. (Murta, 1931, p.157)

[11] Ao lado da pobreza e, em geral, das condições materiais que incitam à exclusão e à diminuição da cidadania, devem também sublinhar-se, crescentemente, os factores culturais de exclusão entre os quais a privação de cultura científica e tecnológica assume hoje uma gravidade ímpar. (Gago, 1996b)

[12] É pela Sociedade da Informação crescentemente partilhada e acessível, mobilizada para o emprego e a modernização da administração e das empresas, para a difusão da cultura e o combate à exclusão, para o progresso científico e técnico e para a interligação de Portugal com o mundo, que entendemos preparar o lançamento de uma grande Iniciativa Nacional para a Sociedade da Informação. (Gago, 1996a)

[13] This 'crisis' is very well discussed in Waring (1979a, 1979b).

Chapter 4

[1] A educação intercultural e a educação cívica deverão estar presentes em cada momento das actividades das escolas, garantindo a todos uma aprendizagem de identidade e de responsabilidade numa sociedade cada vez mais aberta, multifacetada e, por vezes, paradoxal. (DEB, 1998)

[2] A Educação Intercultural é uma nova perspectiva educativa vocacionada para:

1. um melhor acolhimento aos alunos de origem estrangeira ou aos nacionais de vivências socioculturais diferentes;
2. facultar o ensino da Língua Oficial (Português) como Língua Não Materna, assumindo-a como uma língua viva aberta a interferências;
3. accionar processos que ajam directamente em benefício da autoestima, a auto-imagem e a autoconfiança dos 'diferentes';
4. a partilha de conhecimentos, valores, expressões estéticas, técnicas, cultos de cada cultura, incentivando a reflexão sobre as diversidades, as dimensões comuns, as riquezas e os preconceitos patentes;

5. a abordagem, por parte das escolas, dos conteúdos educativos na perspectiva de transmitir a herança multicultural em si presentes, ajudando os jovens cidadãos a crescer na interdependência, na solidariedade, na mediação, na tolerância activa. (DEB, 1998)

[3] In this section references are taken from several American scholars. Quite often they use the term multicultural instead of intercultural. For the sake of the discussions in the section, the two terms are considered in an equivalent form.

[4] WMS stands for western modern science.

[5] This programme will be further discussed in Chapter 6.

Chapter 6

[1] Portugal became an independent kingdom in the Iberian Peninsula by 1114. It was only under Spanish administration from 1580 to 1640.

[2] ... Qualquer distinção, exclusão, restrição ou preferência em função da raça, cor, ascendência, origem nacional ou étnica, que tenha como objectivo ou produza como resultado a anulação ou restrição do reconhecimento, fruição ou exercício, em condições de igualdade de direitos, liberdades e garantias ou de direitos económicos, sociais e culturais. (Presidência do Conselho de Ministros, 1999)

[3] Facilitar a recepção e a transferência das pensões de reforma para os países de origem dos imigrantes. (Governo, 1999)

[4] Ao lado da pobreza e, em geral, das condições materiais que incitam à exclusão e à diminuição da cidadania, devem também sublinhar-se, crescentemente, os factores culturais de exclusão entre os quais a privação de cultura científica e tecnológica assume hoje uma gravidade ímpar. (Gago, 1996b)

[5] Um desses objectivos é o combate à info-exclusão (...). Este projecto contribuirá também para o reforço da identidade cultural e perspectivas de vida das populações envolvidas, bem como para a sua integração numa sociedade da informação aberta e pluralista. (MCT, 1998)

[6] É pela Sociedade da Informação crescentemente partilhada e acessível, mobilizada para o emprego e a modernização da administração e das empresas, para a difusão da cultura e o

combate à exclusão, para o progresso científico e técnico e para a interligação de Portugal com o mundo, que entendemos preparar o lançamento de uma grande Iniciativa Nacional para a Sociedade da Informação. (Gago, 1996a)

[7] A política nacional de I&D é um dos garantes da modernização e desenvolvimento económico, social e cultural do País, constituindo parte integrante da estratégia nacional de aproveitamento e valorização do conjunto dos recursos nacionais de todos os tipos, da promoção da inovação e da expansão do saber. (Governo, 1988, p.3363)

[8] Entendemos que a difusão da cultura científica, a sua apropriação pelo maior número de indivíduos, o nosso envolvimento social nos processos de civilização que a ciência, directa ou indirectamente torna possíveis, são condições fundamentais mínimas para a cidadania moderna. (Gago, 1996b)

[9] Sucessivas gerações de cientistas, professores, estudantes e outros cidadãos esclarecidos e generosos bateram-se, em condições difíceis, pelo desenvolvimento da cultura científica e tecnológica na sociedade portuguesa, sofrendo perseguições e arrostando frequentemente com a incompreensão e o alheamento públicos. Fizeram-no convictos que serviam uma causa de liberdade, de partilha e de progresso. (Gago, 1998b)

[10] O sistema educativo é o conjunto de meios pelo qual se concretiza o direito à educação, que se exprime pela garantia de uma permanente acção formativa orientada para favorecer o desenvolvimento global da personalidade, o progresso social e a democratização da sociedade. (Governo, 1986, p.3067)

[11] Todos os Portugueses têm direito à educação e à cultura nos termos da Constituição da República. (Governo, 1996, p.3068)

[12] Na verdade as preocupações dos anos 80 (em Portugal) diferem consideravelmente quer das preocupações fordistas (...) quer das preocupações 'revolucionárias' (...). Como resultado a escola meritocrática em Portugal que começa nos anos 70 a por de lado o seu estatuto de 'mitigada' (chegando mesmo a ameaçar transformar-se na escola democrática), embarca numa nova fase de desenvolvimento nos anos 80. Esta fase, sob a liderança do 'estado modernizador', passa pela assunção, em Portugal, da crise do fordismo dos países centrais (com a relacionada crise do sistema escolar), ao mesmo tempo que se investe numa continuada consolidação da escola oficial (de massas) para todos. (Stoer, 1994, p.17)

[13] - As dimensões transversal e específica das aprendizagens explicitadas nos objectivos gerais de ciclo;

- o referencial estabelecido nos programas oficiais;

- a componente local e/ou regional do currículo (caso a escola tenha tomado opções nesse sentido). (DGEBS, 1991a, p.2)

[14] Ao Estado cabe definir orientações e metas, regular acções, apoiar iniciativas e incentivar o profissionalismo, assegurando a luta contra as desigualdades e o cumprimento do papel social e cultural da educação, bem individual e colectivo, ao serviço de cada um, de todos e da sociedade.

Acresce que a política educativa tem que se coordenar com outras políticas sociais, nomeadamente na área do Trabalho, da Saúde, do Ambiente, da Ciência, da Cultura e da Administração Interna, por várias razões: pela premência da luta contra a exclusão escolar e social, pelas ligações entre educação-formação e trabalho, pelo carácter universal da escola básica e pelo seu papel inquestionável na formação dos cidadãos. (Governo, 1998)

[15] A educação básica constitui um desafio a que todos os países desenvolvidos dão hoje maior atenção; por um lado, porque os estudos de literacia mostram que só uma formação inicial prolongada, sólida e consistente garante que, quaisquer que sejam os modos de vida, não há regressão nos saberes essenciais; por outro lado, porque a escolaridade básica constitui o começo de um processo de educação e formação ao longo da vida, imprescindível para responder aos novos desafios pessoais e sociais. (Governo, 1998)

[16] Consolidar e estabilizar um currículo nacional comum, promovendo e apoiando a gestão curricular flexível e assegurando, em todos os ciclos, que as actividades de instrução e de educação para a cidadania se combinem de modo consistente e permanente. (Governo, 1998)

[17] Avaliar e desenvolver as experiências de adaptação curricular, quer as que visam primordialmente prevenir a exclusão e o abandono, quer as que, para além deste objectivo, pretendem estabelecer um interface eficaz com o mundo do trabalho, quer, ainda, as que visam assegurar uma educação intercultural. (Governo, 1998)

[18] O Projecto de Educação Intercultural tem como objectivos gerais:

a) Incentivar uma educação intercultural que permita desenvolver atitudes de maior adaptação à diversidade cultural da sociedade Portuguesa;
b) Dinamizar a relação entre a escola, as famílias e as comunidades locais;

c) Incrementar a igualdade no acesso e usufruto dos benefícios da educação, da cultura e da ciência;

d) Considerar e valorizar os diferentes saberes e culturas das populações servidas pelas escolas abrangidas neste projecto. (Ministério da Educação, 1993, p.8313)

[19] a) Elaboração de projectos de turma, com adequada gestão do currículo;

b) Criação de trabalhos de Projecto, com parcerias nacionais e/ou internacionais;

c) Dinamização de Círculos de Formação em contexto profissional;

d) Realização de projectos de investigação-acção. (DEB, 1998)

[20] - Um melhor acolhimento aos alunos de origem estrangeira ou aos nacionais de vivências socioculturais diferentes;

- Facultar o ensino da Língua oficial (Português) como Língua Não Materna, assumindo-a como uma língua viva aberta a interferências;
- Accionar processos que ajam directamente em benefício da autoestima, a autoimagem e a autoconfiança dos 'diferentes';
- A partilha de conhecimentos, valores, expressões estéticas, técnicas, cultos de cada cultura, incentivando a reflexão sobre as diversidades, as dimensões comuns, as riquezas e os preconceitos patentes;
- A abordagem, por parte das escolas, dos conteúdos educativos na perspectiva de transmitir a herança multicultural em si presentes, ajudando os jovens cidadãos a crescer na interdependência, na solidariedade, na mediação, na tolerância activa. (DEB, 1998)

[21] Construir uma Sociedade da Informação e do Conhecimento para todos, tão socialmente inclusiva como competitiva, exigente e aberta, é uma clara prioridade consistentemente assumida pelo Governo. O que está em jogo é decisivo para o futuro do País. Desenvolver aceleradamente a Sociedade da Informação e do Conhecimento é criar condições indispensáveis para trabalho mais qualificado, melhores níveis de vida, para empresas mais competitivas e mais responsáveis, para uma administração pública desburocratizada, mais eficiente e mais transparente, para melhor saúde e para melhor educação e formação. Desenvolver uma sociedade e uma economia baseada na informação e no conhecimento é hoje um imperativo nacional. (Governo, 2001)

[22] - Vencer o atraso;

- Melhorar a qualidade, reforçando a internacionalização e diversificando as parcerias;
- Reforçar a Produção Científica;
- Reforçar a capacidade tecnológica das empresas;

- Consolidar a nova Organização e Funcionamento do Sistema de Ciência e Tecnologia;
- Enraizar a ciência no país e reforçar a Cultura Científica e Tecnológica. (MCT, 1998)

[23] Ciência Viva is a national comprehensive programme for teaching and learning scientific literacy involving formal and non-formal education.

[24] - Tornará obrigatória a aprendizagem experimental das ciências no ensino básico;
- Criará Centros Ciência Viva, espaços interactivos de divulgação científica, em todos os distritos do País e lançará, pelo programa Ciência Viva, uma rede de centros de recursos para a aprendizagem experimental das ciências e das tecnologias, regionalmente distribuída;
- Promoverá um programa nacional de apoio às condições de aprendizagem experimental obrigatória das ciências no ensino básico. (Governo, 1999)

[25] In all the chapters regarding the analysis, the expression modern science is indifferently used as the concept of modern science, and as a designation of the scientific subjects being studied: physics, chemistry, and biology.

[26] 1. À Descoberta de Si Mesmo.
2. À Descoberta dos Outros e das Instituições.
3. À Descoberta do Ambiente Natural.
4. À Descoberta das Interrelações entre Espaços.
5. À Descoberta dos Materiais e Objectos.
6. À Descoberta das Interrelações entre a Natureza e a Sociedade. (Ministério da Educação, 1990)

[27] Área Temática A – Nós e o Universo
Área Temática B - Produção, Distribuição e Utilização da Electricidade
Área Temática C – O Som e a Audição
Área Temática D – A Luz e a Visão
Área Temática E – Produção e Consumo de Energia
Área Temática F – Transportes e Segurança
Área Temática G – Radiação e Ambiente
Área Temática H – Controlar e Regular
Área Temática I – Atmosfera e Mudanças de Tempo (DEB, 1995)

[28] 1. Nós e o Meio Material
2. Substâncias Químicas: o que são, o que se faz com elas

3. Transformações Químicas e o Meio à Nossa Volta (DEB, 1995)

[29] 1. Como a Matéria É em Mais Pormenor

2. Transformações Químicas e o Meio à Nossa Volta

3. Organização dos Elementos Químicos e a Diversidade em Química

4. A Química e o seu Impacte na Sociedade: uma primeira retrospectiva (DEB, 1995)

[30] Reconhecer fenómenos:

- de condensação (nuvens, nevoeiro, orvalho)
- de solidificação (neve, granizo, geada)
- de precipitação (chuva, neve, granizo) (Ministério da Educação, 1990, p.82)

[31] Aplicar noções operatórias elementares de espaço, tempo e quantidade (número, proporcionalidade, distância, tempo linear, ...) na percepção e interpretação de factos e situações concretas. (DGEBS, 1991a, p.31)

[32] Compreender a importância da classificação biológica como modo de organizar e sistematizar a diversidade dos seres vivos. (DGEBS, 1991b, p.9)

[33] Revelar atitudes de respeito e de solidariedade para com pessoas e grupos de idade, sexo, raça e origem social diferentes, bem como pessoas e povos de outras culturas, apreciando os seus costumes, produtos de expressão e tecnologia. (DGEBS, 1991a, p.34)

[34] Aplicar noções operatórias de espaço, tempo, quantidade (número, função, velocidade, multiplicidade temporal, ...) na organização e interpretação dos dados do conhecimento. (DGEBS, 1991a, p.36)

[35] Demonstrar compreensão e solidariedade para com povos, grupos, pessoas, valorizando as diferenças culturais (práticas, costumes, expressões artísticas, tecnologias, ...) e denuncinado atitudes e situações discriminatórias e injustas. (DGEBS, 1991a, p.40)

[36] Na sua dimensão científica, a disciplina de FQ deve proporcionar a aquisição dos conceitos, leis, teorias e modelos característicos da Física e da Química necessários à compreensão global do Universo e do mundo que nos rodeia (...). (DEB, 1995, p.8)

[37] Estimular nos jovens o interesse, a curiosidade e o apreço pelo estudo dos fenómenos naturais e pela interpretação do meio físico onde estão integrados. (DEB, 1995, p.9)

[38] Realizar experiências que sugiram que a matéria é constituída por corpúsculos em incessante movimento.

Inferir o pequeníssimo tamanho dos corpúsculos constituintes da matéria.

Distinguir estados físicos da matéria em termos da agregação corpuscular. (DEB, 1995, p.54)

[39] Compreender que a Terra pertence a um sistema planetário dependente do Sol.

Identificar o sistema solar como uma parte do Universo. (DGEBS, 1991c, p.9)

[40] Reconhecer a interacção dos diferentes sistemas na unidade do organismo.

Compreender conceitos de morfologia e fisiologia humana necessários à abordagem de problemas de saúde. (DGEBS, 1991b, p.20)

[41] - As funções vitais envolvem processos de renovação celular, ultização de energia, transporte de materiais e eliminação de produtos nocivos.

- O sistema neuro-hormonal assegura a coordenação de todas as funções essenciais à vida.
- A reprodução humana envolve processos biológicos específicos e implica responsabilidades que se impõe conhecer. (DGEBS, 1991c, p.23)

[42] A pesquisa dos meios de contracepção constitui uma aplicação directa das noções de fisiologia. Salientar particularmente a necessidade de respeitar o calendário que os métodos hormonais implicam. Na regulação de nascimentos, objecto da contracepção, deve ser salientado o sentido do respeito pela vida e o das responsabilidades individuais e sociais. (DGEBS, 1991c, p.28)

[43] Vivemos mergulhados num 'oceano' de radiações provenientes do Sol, do espaço... (DEB, 1995, p.68).

[44] Depois de se recordar, através da experiência, que a matéria é constituída por corpúsculos em permanente movimento (...). (DEB, 1995, p.17)

[45] Como são constituídas as substâncias.

Natureza corpuscular da matéria.

Agregação e movimentos corpusculares. (DEB, 1995, p.54)

[46] Deve apresentar-se uma visualização correcta do átomo em detrimento do estudo de modelos teóricos de interesse histórico. (DEB, 1995, p.75)

[47] Nesta unidade temática desenvolve-se uma primeira incursão no mundo microfísico, designadamente sobre a constituição da matéria ao nível da estrutura de átomos e moléculas e respectivos agregados, em relação com algumas propriedades. Começa-se, assim, a dar resposta a questões do tipo 'como é que as coisas são "por dentro"?' (DEB, 1995, p.18)

[48] A Química como resposta a questões sobre o mundo material.
A Química é uma ciência fascinante.
As primeiras experiências e observações em Química.
As questões a que a Química responde.
A Química e as solicitações do Homem e da Sociedade. (DEB, 1995, p.50)

[49] - Observar cuidadosamente os factos, com vista à sua compreensão, corrigindo intuições perceptivas.
- Relacionar e organizar factos, objectos e situações, através da sua seriação e classificação.
- Identificar propriedades, dissociando os dados da experiência concreta, e fazer generalizações simples em situações delimitadas.
- Realizar pequenas cadeias de raciocinio com vista à resolução de problemas, relatando as etapas percorridas.
- Explicar situações novas, de natureza concreta e próximas da sua área de experiência, através de observações cuidadas e do estabelecimento de associações e semelhanças. (DGEBS, 1991a, pp.8-9).

[50] Para atingir o domínio dos conceitos não é necessário que todos os alunos tenham de percorrer os mesmos caminhos. No entanto, pretende-se que todos se vão tornando observadores activos com capacidade para descobrir, investigar, experimentar e aprender. (Ministério da Educação, 1990, p.68)

[51] Revelar capacidade de observar e ordenar observações.
Interpretar dados e tirar conclusões.
Revelar a capacidade de aprender a pensar. (DGEBS, 1991b, p.9)

[52] - Aplicar noções operatórias elementares de espaço, tempo e quantidade (número, proporcionalidade, distância, tempo linear, ...) na percepção e interpretação de factos e situações concretas.
- Proceder à observação cuidadosa dos factos, em diversos contextos, tendo em vista a sua descrição e interpretação.

- Fazer generalizações, a partir de conjuntos de dados simples de modo a determinar regras e propriedades.
- Respeitar os procedimentos lógicos básicos do raciocínio dedutivo na resolução de problemas.
- Justificar procedimentos e conclusões, com base em conhecimentos, factos e dados experimentais ou documentais.
- Interpretar situações novas, de natureza concreta e próximas da sua área de experiência, mediante a associação e comparação com situações já conhecidas. (DGEBS, 1991a, pp.8-9)

[53] - Aplicar noções operatórias de espaço, tempo, quantidade (número, função, velocidade, multiplicidade temporal, ...) na organização e interpretação dos dados do conhecimento.
- Realizar observações rigorosas, utilizando os procedimentos requeridos pelas diferentes áreas do conhecimento científico, tendo em vista a análise e interpretação dos factos.
- Inferir regras, propriedades e relações gerais, a partir da análise de factos e situações.
- Inferir consequências de princípios, utilizando o raciocinio dedutivo, na resolução de problemas, em demonstrações matemáticas simples e na verificação de hipóteses.
- Aplicar conceitos, generalizações, teorias e modelos, na explicação de situações, fenómenos e processos relativos a diferentes domínios da realidade. (DGEBS, 1991a, pp.8-9)

[54] Na sua dimensão científica, a disciplina de FQ deve proporcionar a aquisição dos conceitos, leis, teorias e modelos característicos da Física e da Química necessários à compreensão global do Universo e do mundo que nos rodeia e deve priviligiar os processos que lhe são inerentes. Estão neste caso a procura de relações causais, a experimentação, a descrição quantificada e explicação de resultados de observações e experiências, a dedução das consequências de uma dada teoria, a previsão de resultados com base numa hipótese, o planeamento de uma experiência para testar uma ideia, a prática de ajuizar as incertezas introduzidas numa medição (directa ou indirecta) ou, ainda, a reflexão sobre os resultados experimentais (DEB, 1995, p.8)

[55] Reconhecer a importância da observação e da experimentação aliadas à reflexão e ao campo das ideias. (DEB, 1995, p.50)

[56] A curiosidade infantil pelos fenómenos naturais deve ser estimulada e os alunos encorajados a levantar questões e a procurar respostas para elas através de experiências e pesquisas simples. Os estudos a realizar terão por base a observação directa, utilizando todos os sentidos, a recolha de amostras, sem prejudicar o ambiente, assim como a experimentação. (...) É importante que, desde o início, os alunos façam registos daquilo que observam. (DGEBS, 1991a, p.79)

[57] Com este bloco pretende-se desenvolver nos alunos uma atitude de experimentação permanente com tudo o que ela implica: observação, introdução de modificações, análise e compreensão de efeitos e resultados, conclusões. (Ministério da Educação, 1990, p.87)

[58] Comparar materiais segundo algumas das suas propriedades (flexibilidade, resistência, solubilidade, dureza, transparência,...).
Agrupar materiais segundo essas propriedades. (Ministério da Educação, 1990, p.88)

[59] Comparar e classificar plantas segundo alguns critérios tais como: cor da flor, forma da folha, (...).
Comparar e classificar animais segundo as suas características externas e modos de vida. (Ministério da Educação, 1990, p.81)

[60] Classificação dos seres vivos.
Importância da classificação.
Como classificar os seres vivos. (DGEBS, 1991b, p.15)

[61] Elaboração de chaves de classificação relativas à diversidade de relações entre os seres vivos com indicação dos respectivos critérios. (DGEBS, 1991c, p.18)

[62] Reconhecer o valor das conquistas científicas e técnicas para o progresso das sociedades humanas. (DGEBS, 1991a, p.34).

[63] It involves Citizenship Education.

[64] Compreender as implicações da Ciência, no dia-a-dia da actividade humana. (DGEBS, 1991b, p.9)

[65] Dominar conhecimentos básicos no domínio da Física e da Química necessários à interpretação científica dos fenómenos físicos e de aspectos tecnológicos importantes na sociedade actual.
Dominar conhecimentos básicos no domínio da Física e da Química necessários a uma actuação quotidiana esclarecida e responsável, quer no que se refere à utilização de aparelhos e equipamentos comuns, quer no que se refere a decisões práticas sobre usos e consumos que podem afectar a comunidade local e/ou global.
Reconhecer a importância das contribuições da Física e da Química na melhoria da qualidade de vida. (DGEBS, 1991a, p.38).

[66] Valorizar os contributos do desenvolvimento científico e tecnológico para o progresso histórico das sociedades, analisando criticamente as implicações desse desenvolvimento na sociedade actual. (DGEBS, 1991a, p.39)

[67] O mundo actual está constantemente a ser modificado pela descoberta de novos conhecimentos. Grandes inovações científicas e tecnológicas tornaram possível o sucesso das nossas sociedades, o qual depende, mais do que nunca, da eficácia com que aqueles conhecimentos são usados, da capacidade de introduzir inovações em todos os domínios e, ainda com maior premência, da capacidade de praticar uma reflexão crítica potenciadora de decisões acertadas e esclarecidas tendo em vista o futuro global da humanidade. (DEB, 1995, p.7).

[68] Ilustrar a importância da Química como resposta a solicitações do Homem e da Sociedade. (DEB, 1995, p.50)

[69] Compreender que a regulação dos nascimentos deve envolver o respeito pela Vida e o sentido da responsabilidade como cidadão.
Reconhecer as implicações das novas tecnologias no domínio da reprodução do Homen. (DGEBS, 1991c, p.9)

[70] A Química como resposta a questões sobre o mundo material.
As questões a que a Química responde.
A Química e as solicitações do Homem e da Sociedade. (DEB, 1995, p.50)

[71] 1. Química e Indústria.
2. Química e Ambiente
3. Química e Agricultura
4. Química e Saúde
5. Química e Defesa do Consumidor (DEB, 1995, p.18)

Chapter 7

[1] For a discussion on issues of risk, modernity and modern science see for example: Beck-Gernsheim (1996), Diani (1996), Maguire (1996) and Berking (1996).

[2] - Specific attacks on progressive forms of pedagogy and curriculum development particularly those perceived as threatening the status quo.
- Intention to re-affirm traditional values and cultural traditions which have been felt to have weakened.
- The intention to establish a set of boundaries for what is considered English. (Jones and Kimberley, 1991, pp.13-4).

[3] See for example: Street-Porter (1978), Gillborn (1999), Grant (1997), Gundara, (2000a).

[4] The three modern science subjects are considered for students taking GCSE courses in all the three separate sciences of biology, chemistry, and physics.

[5] The various units, which constitute the QCA Scheme of Work for Science are of an individual nature. There are no page numbers in them. Consequently, no reference can be made to them.

[6] Single Science and Double Science are analysed together because the two programmes share the same format, orientation, nature and kind of content. They differ in the level of depth by which content is considered. Double Science involves a more detailed study of the same content as Single Science. The examples presented in the analysis are from both programmes.

[7] Unit 3 – Characteristics of Materials.

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