THE SIMULATION METHOD:

A TEACHING TECHNIQUE FOR
ENVIRONMENTAL EDUCATION
IN SECONDARY SCHOOLS

BY

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ABSTRACT

The need to establish teaching techniques for Environmental Education in the South African secondary school context was perceived. The simulation method was identified as one such technique which became the focus of this study, because it was believed by the researcher to be compatible with the aims and objectives of Environmental Education. A simulation activity aimed at Standard 9 pupils was devised (based on a particular environmental issue i.e. nuclear vs coal-powered electricity generation). To demonstrate that this activity could affect pupils' environmental knowledge, concepts, attitudes and behavioural intentions, a series of 3 questionnaires was designed to capture the results of the simulation activity.

A pilot test was conducted using both the simulation activity and the questionnaires. The results of the pilot test were then analysed after which appropriate changes were made, particularly concerning ambiguity and design problems in the questionnaires.

The revised simulation activity and questionnaires were then implemented in 8 Cape Education Department English-speaking secondary schools with a sample population of some 206 pupils.

Results analysed from the 3 questionnaires indicated that statistically significant changes had occurred among the pupils. This confirmed that the simulation activity could be utilised as a means of teaching various aspects of environmental education. However, the research also showed that the simulation activity is a teaching technique which needs to be used in conjunction with other supportive methodologies.

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CHAPTER ONE

INTRODUCTION

1.1 THE PROBLEM

1.1.1 Need for an Effective Teaching Method for Environmental Education

There is in South African secondary schools the need for an effective teaching method for Environmental Education. Because, although Environmental Education (EE) is a recent development in the educational milieu, its importance and value has yet to be fully recognized by secondary school educators in South Africa.

It is the considered opinion of this researcher, based on 8 years teaching experience that there are five main reasons for this lack of recognition. Firstly, indecision still prevails nationally as to whether EE is an additional school subject or rather an interdisciplinary educational approach. Secondly, the problem of confusing Conservation Education with that of EE still abounds. Thirdly, EE is not regarded by State Education authorities as a priority, possibly because of the conservative confines of the policy of Christian National Education, which might regard EE as revolutionary, especially when one of the aims of EE refers to changing people's attitudes (Connect, 1976, p.70). Fourthly, the belief is still widespread in South Africa that the human-environmental crisis is not critical, especially as far as South Africa is concerned. Lastly, proven teaching methods for EE are largely unsuitable for use in South African secondary schools because of the Eurocentric or North American design of these methods.

It is imperative, in the view of the researcher, to establish and demonstrate the value of at least one teaching method for EE which could be appropriately used in South African secondary schools.

1.2 THE AIM OF THIS RESEARCH

1.2.1 The Primary Aim

The aim of this research project is to design a simulation activity for the teaching of EE in South African secondary schools.

Despite the holistic nature of EE the researcher decided to concentrate on one particular environmental issue (i.e. the coal/nuclear issue). The reasons for this are as follows:

(a) that it is not within the scope of this study to test every aspect of EE;

(b) that the success of the simulation technique be more easily proven by dealing with one environmental issue rather than the complexity of many issues;

(c) that the success achieved with regard to one aspect of EE (and simulation activities) might lead one to extrapolate that similar results could also be achieved in other EE contexts.

The goal of EE as set out in the Belgrade Charter of 1975 states that EE should be able

> "to develop a world population that is aware of and concerned about, the environment and its associated problems, and which has the knowledge, skill, attitudes, motivations and commitments to

work individually and collectively towards solutions of current problems and the prevention of new ones" (UNESCO-UNEP, 1976, p. 70).

Thus, due to EE having cognitive, affective and conative components, the simulation activity would have to be designed in such a way as to be able to test pupils in all three domains. In order to assess the effectiveness of the simulation activity an appropriate method would have to be found.

1.2.2 Motivation for Designing a Simulation Activity for Environmental Education

It is the belief of the researcher that the simulation teaching method can make a valuable contribution to the promotion of EE in South Africa. This view is also supported by the UNESCO - UNEP International Environmental Education Programme which suggests that "gaming and simulation seem particularly suitable for environmental education" (Taylor, 1987, p.5).

As no previous research was found to have been published in this field in South Africa, the results of this exercise will be important, if not only because they break new ground.

1.3 PROCEDURE TO BE ADOPTED

1.3.1 Designing a Simulation Activity for Environmental Education

The approach adopted in this research project was first to establish whether or not any simulation activities were in existence or use in South Africa. A simulation activity called 'The Environment Game', which had been used in pre-independence Zimbabwe, proved to be a useful starting point. It was decided after careful consideration to use only part of this game as the basis for the development of a more South African orientated simulation activity.

The design of the simulation activity was thus done according to the 'reusable' simulation design method. Other features of the simulation activity were that it had to conform to the aims and objectives of EE, and it had to be centred around a South African environmental issue (in this case, coal-fired power stations vs nuclear powered ones). The simulation activity was thus called 'Coal or Nuclear'.

1.3.2 Designing a Means of Assessing the 'Coal or Nuclear' Simulation Activity

A set of three questionnaires was devised to assess the effectiveness of the simulation activity in terms of the tripartite nature of EE. The questionnaire method was preferred above that of the more traditional methods such as 'chalk and talk' because, the researcher felt that it displayed the following advantages:

(a) it is easy to administer;
(b) it requires only a short time to administer;
(c) it facilitates the easy collection of the pupils' responses to questions; and
(d) it enables the efficient gathering of information dealing with changes in pupils' concepts, knowledge, attitudes and behavioural intentions.

1.3.3 Selection of Schools and Pupils

1.3.3.1 Choice of Schools

The researcher would have preferred to have selected a varied, yet randomly chosen sample from all South African schools (i.e. from all fifteen education departments). Due to the sensitive nature of this issue while in the employ of the Cape Education Department (C.E.D.), it was therefore decided that the final selection of schools had to be based on the researcher's teaching experience at the time, despite its apparent limitations. It was for this reason that the research was carried out in White, co-educational, English-speaking, C.E.D., secondary schools. The necessary permission granted (see Appendix 9), the researcher then had to approach individual headmasters for permission to carry out the research in their schools. After two rejections, because of examination and other commitments eight schools agreed to take part in the research project.

1.3.3.2 Choice of Pupils

The researcher decided to use a standard nine register class. Standard nine pupils would be approximately 16 years old and in their second last year of secondary school in a 12 year school system. The significance of using a register class was that it would contain pupils who took subjects representative of a cross-section of Standard nine, so necessary in terms of the cross-curricular nature of EE.

Another reason for these choices was that the pupils would, according to Piaget have reached an intellectual stage of mental development referred to as 'formal operations' whereby they would be capable of dealing with advanced cognitive, affective and conative processes, also necessary in terms of EE (Elkind, 1976, p.98).

1.3.4 Implementation of the Pilot Study and Refining of the Simulation Activity and Questionnaire

For the pilot study the researcher chose the English-medium, co-educational secondary school at which he taught in Cape Town. The pupil population was considered to be representative of the sample population.

The pilot study was implemented soon after the necessary permission had been acquired. A thorough analysis of the pupil's responses and reactions to the simulation activity and questionnaires was carried out. As a result of these observations the simulation activity and questionnaires were refined so as to be shorter and more appropriate. The simulation activity and the questionnaires were then administered by the researcher to some 208 standard nine pupils at the eight schools mentioned in section 1.3.3.1.

Chapter Two, which follows, discusses the dimensions of the human-environmental crisis and the part that EE can play in alleviating some aspects of this crisis.

CHAPTER TWO

THE HUMAN-ENVIRONMENTAL CRISIS

2.1 DIMENSIONS OF THE HUMAN-ENVIRONMENTAL CRISIS

An appreciation of the natural environment and a concern for its preservation have long been recognised. However, before investigating ways of solving the environmental crisis, it is important to recognise that the crisis does not pertain only to isolated problems in the natural environment. It also encompasses issues such as the 'population explosion' and poverty. As most of these problems are a direct result of human impact on the natural environment, or are human/environment related, it is possibly more appropriate to speak about a human-environmental crisis, rather than an environmental crisis. The crux of the matter is that people must be made aware that earth is facing

> "a multifaceted, global crisis that touches every aspect of our lives: our health and livelihood, the quality of our environment and our social relationships, our economy, technology [and] our politics ..." (Spretnak and Capra, 1985, p. xv).

It was only during the 1960's and early 1970's that the rate of environmental degradation became a possible cause for alarm. Many scholars, among them Carson (1962), Commoner (1966), Ehrlich (1969), and Ward and Dubos (1972) warned of the dangers of continued population increase, rapid and unchecked technological advances, and the resultant pollution of water, land, air and living organisms. These scholars further explained that if nothing was done to alleviate these serious environmental problems, human survival on earth could well be in jeopardy.

The warnings contained in their books became harsh reality with the advent of world-wide television coverage. Some of the better documented environmental disasters covered during this period include:

(a) the Windscale nuclear accident (1957) in the United Kingdom, in which some 800 square kilometres of land were contaminated and twenty people are said to have died from exposure to nuclear radiation (Myers,1985, p. 124);

(b) the Minamata mercury poisoning incident (1960) in Japan, in which some two thousand people were crippled, while apparently four hundred died as a result of mercury poisoning (Lean, 1986, p. 21);

(c) the Torrey Canyon disaster (1967) when an oil tanker ran aground off the coast of Cornwall (U.K.) spilling approximately 117 000 tonnes of oil (Dafter, 1981, p. 25).

These problems in the media highlighted a concern for the state of the environment and visibly portrayed the vast dimensions of the human-environmental crisis. An environmental awareness and concern developed, mainly within the academic circles of Western society in response to this crisis (Fritsch, 1980, p. 3). However, the majority of people in the world remained ignorant of this crisis. It is necessary, therefore, to convince people without being too apocalyptic, that a human-environmental crisis does exist. More importantly, it is crucial to explain that, as a human-environmental crisis, it must be solved by people.

2.2 FACTORS CONTRIBUTING TO THE HUMAN-ENVIRONMENTAL CRISIS

The following are considered, in the view of this researcher, to be some of the major causes of the human-environmental crisis because they collectively contribute to this crisis:-

(a) The population explosion and rapid depletion of the earth's natural resources;

(b) The energy crisis;

(c) The pollution of air, water and land;

(d) Soil erosion;

(e) Poverty; and

(f) Ignorance and dissension as to the cause and effect of human impact on the environment.

2.2.1 The Population Explosion and the Rapid Depletion of the Earth's Natural Resources

Possibly the most basic cause of the human-environmental crisis is the population explosion and the demands this has made on a finite planet. It is not merely numbers that are a problem, but rather the relationship between them and the availability of the earth's natural resources. The importance of this relationship is evident in that humans live in a complex, yet interconnected, web of biological and physical conditions. In order to survive, humans need to satisfy basic needs: air, water, light, warmth, shelter, food and clothing. All these needs can be adequately supplied from the earth's natural resources base. However, most of the earth's resources are finite.

Historically-speaking the population explosion is a recent occurrence. World population growth was slow initially, with the figure rising to approximately 100 million by 500 B.C., increasing to 500 million by 1300 A.D. The rapid growth in population resulting from the Industrial Revolution in Britain began during the late 18th and early 19th centuries (1000 million being reached in the early nineteenth century). Since then world population has escalated at a phenomenal rate, reaching 4000 million by 1975 and 5000 million by 1987 (Goldsmith and Hildyard, 1988, p. 200). In 1985 predictions were made that by the year 2000 the world population should reach 6400 million (Myers, 1985, p. 180). However, it seems likely that this figure might well be surpassed before the end of the 20th century (based on the rapid increase between 1975 and 1987).

It is indeed difficult to make accurate predictions of future population figures, although it is evident that the world population is growing rapidly. Two important demographic facts must, however, be taken into account:

(a) Thirty thousand million is regarded as the maximum carrying capacity of the earth;

(b) Ten thousand million is the ceiling at which human life "can be supported with any degree of comfort and decent standard of living ..." (Hurry, 1987, pp. 1-2).

The rapid increase in population growth will put tremendous strain on the earth's resources. Resources may be regarded as either renewable or non-renewable. The dividing line between these two areas is not always clear. For example, vegetation might initially be regarded as a renewable resource, but poor management and over-exploitation could result in it becoming a non-renewable resource. Thus, the ever-increasing world population, in its escalating demand for and consumption of the earth's resources, could well upset the balance between renewable and non-renewable resources, as well as condemn some non-renewable resources into economic extinction.

The problem is further compounded by the unequal distribution of the earth's natural resources. This results in global inequalities in terms of wealth and poverty. The world, in relation to this global imbalance in natural resources can be divided into two unequal halves, the 'haves' and the 'have-nots'. According to Reed (1985) approximately nine-tenths of the world's wealth (which is directly related to the amount of economically valuable natural resources (such as coal) is controlled, if not possessed by the North ('haves') while the South ('have-nots') with seven-tenths of the total world population has one-tenth of this wealth or the ability to control wealth. Therefore, the population-resources problem is related not only to the density of people, but more so to the distribution and availability of resources. This imbalance and the increase in population (particularly in the South) can only further exacerbate the growing global crisis.

2.2.2 The Energy Crisis

2.2.2.1 Introduction

The energy crisis is inextricably connected with population growth, the unequal distribution of the world's natural resources, and the resultant division of the world into two disparate 'halves'. Because of its complex nature the energy crisis is not easy to define. Energy cannot be destroyed and yet one talks of an energy crisis. The crisis lies not with Earth running out of energy, but rather the depletion of its finite, non-renewable fossil fuels used to produce energy. The energy crisis as such has been caused by the ever growing world population's insatiable demand for more power. Mckie (1984, p.5) adds that politicians and scientists have calculated that "since 1900 energy consumption has increased tenfold - and that rise is bound to continue...".

The shortage of fossil fuels has forced many countries to consider alternative energy sources such as nuclear power, wind power, wave power, geothermal power, solar power, tidal power and hydro-electric power.

2.2.2.2 The Depletion of Fossil Fuels

Energy's being the basis for all life results in the world's consuming large quantities of fossil fuel resources. The energy crisis has developed specifically out of the fear that the present rate of consumption of the earth's limited supply of fossil fuels is going to result in world-wide energy shortages. In 1973 when the Organisation of Petroleum and Exporting Countries (OPEC) introduced high oil prices world-wide and also threatened a cutback in their production of the world's main source of crude oil thus, many countries dependent on oil, particularly in North America and Western Europe, began to reduce their consumption and introduce conservation measures. (Robinson, 1981, p. 111).

One may thus ask: Is there still an oil crisis? The answer is yes, but oil may never really 'run out', yet it will have to be supplemented if not replaced by alternative energy sources because "it would be grossly misleading to suppose that our present oil consumption can be maintained for very long" (Goldsmith and Hildyard, 1988, p. 192).

Coal, another finite fossil fuel, sometimes referred to as 'King Coal' because of its importance as an energy producer, also faces the prospect of becoming too expensive to exploit, because the present demands for coal far outstrip the earth's supplies of it.

Other fossil fuels such as natural gas and tar sands can offer energy supplies for the immediate future; however, they too will not be economically viable for long either (Myers, 1985, p. 112).

The use of fossil fuels to produce energy also has detrimental effects on the environment, such as acid rain and excessive amounts of carbon dioxide being pumped into the atmosphere which has possibly increased global temperatures, creating the so-called 'green-house effect'. Many countries in the developing world have added problems because they have to resort to burning wood in order to supplement their energy needs.

2.2.2.3 The Fuelwood Crisis

Pye-Smith (1984) estimates that approximately "two billion people - about half the world's population [in 1984] - depend on firewood for fuel" (Pye-Smith, 1984, p. 16). Thus, countries in the 'South' not only face the possible loss of their main fuel source because of a rapidly 'exploding population, but they are also increasing air pollution and reducing valuable woodlands within their borders. The finite nature of the earth's fossil fuels and the rapid depletion of forests for firewood in the developing world means that alternative energy sources will have to begin to replace these in the not too distant future.

2.2.2.4 The Pros and Cons of Nuclear Power

Nuclear power is seen as an important alternative energy source. Proponents of nuclear power stress that nuclear power stations run on an inexpensive fuel which, if successfully manufactured in fast breeder reactors, could provide an almost endless supply of fuel (McKie, 1984, p.46). They also claim that this form of nuclear energy can supply electricity without polluting the environment in the process (Lean, 1986, p.16). However, there are risks which must be weighed up against the possible benefits.

Based on the benefits of nuclear power, a number of countries such as the U.S.A., Britain, France, Japan and South Africa, subsequent to 1972, embarked upon nuclear programmes (Myers, 1985, p. 124). Meanwhile, opponents of nuclear power contend that

> "far from providing a cheap and plentiful supply of energy that would satisfy world demand for the foreseeable future, it has provided us with an expensive energy source fraught with intractable technical problems and unacceptable environmental risks" (ibid, 1985, p. 124).

These risks are associated with the inability of the nuclear industry to dispose of radioactive waste products safely, and the risk of plutonium (a by-product of all nuclear reactors) being misappropriated by terrorists and made into nuclear bombs.

The Chernobyl disaster in the Soviet Union in April 1986 highlighted the need for care and safety when dealing with nuclear power. After the accident the percentage of people against nuclear power (according to opinion polls) escalated dramatically. For example in the United States 67 % were in opposition to the building of new nuclear power stations before Chernobyl and 78 % after. In West Germany the change was more dramatic; from 46 % to 83 % (ibid, 1985, p. 46).

2.2.2.5 Other Alternative Energy Sources

A possible solution to the energy crisis is to research and develop as many environmentally 'safe' alternative sources of energy as is economically feasible, such as solar, wind, geothermal, wave, and hydro-electric power. While the U.S.A. (and other countries in the North) consume most of the world's stock of fossil fuels, as well as being able to develop alternative energy sources, countries in the South face increasing energy problems because they do not possess the resources, technology or finance to deal with these problems.

In the interim the world will have to continue using the existing energy sources until economically viable, low polluting alternatives can be found. Stricter energy conservation methods could be applied, while a global energy assistance programme could be instigated to help countries in the South overcome their energy problems. More stringent international and national regulations also need to be drawn up to prevent further energy related pollution of the environment.

2.2.3 Pollution of the Air, Water and Land

Pollution of the three most important life-supporting elements (i.e. air, land and water) together with others has been happening since the beginning of human history. However, widespread and increasing levels of pollution began to emerge only during the 19th century with the advent of the Industrial Revolution in Britain.

Each of these areas will now be more closely examined, with a brief synopsis of the extent to which present-day pollution levels are contributing to the human-environmental crisis.

2.2.3.1 Air pollution

Air is continually being abused through pollution as a result of industrial and energy-producing processes. The consequences of this continued pollution of the atmosphere is varied. The build-up of carbon dioxide could lead to changes in world climatic patterns due to rises in temperature. This in turn could result in the polar ice-caps melting with a resultant rise in the sea-level around the world (Lean, 1986, p. 13).

Evidence supporting the fact that air pollution or the effects of air pollution can kill or contribute towards increasing illness particularly affecting humans was realised after the Bhopal disaster (in central India) on December 2, 1984 and the Chernobyl disaster (in the USSR) on April 26, 1986 (Goldsmith and Hildyard, 1988, p.119).

Acid rain, on the other hand, appears to be an universally accepted problem because it has caused the destruction of sections of forest in many European countries.

Another problem is the fear that continued air pollution is destroying the ozone layer (which serves as a natural filter against dangerous ultra-violet rays from the sun). The gravity of this environmental problem resulted in the signing of an international treaty (by 27 countries in Montreal in September 1987) to try and solve this predicament (New Scientist, 1987, p. 22).

The signing of this treaty although showing a deep concern by many countries for the protection of the ozone layer also exhibits an attitude of dealing only with selected problems which affect them directly. This attitude is a piecemeal approach to solving these inter-related problems.

2.2.3.2 Water pollution

Regarding the unequal distribution of the earth's natural resources, the availability, quantity and quality of water differs from country to country. Despite these differences water is further subjected to pollution. The fact that water is circulated within the biosphere means that pollution at any particular stage of this circulation may be carried over into other areas of the system. The hydrological cycle indicates that theoretically water can never be used up, but if the water is subjected to ever-increasing pollution, the fresh- water quota will be severely reduced. Humans appear oblivious to the consequences of water pollution because the waters of the earth (oceans, seas, rivers, ground water and lakes) continue to be polluted with sewage, chemicals, toxic metals, radioactive substances, and heat from industry, to the point where rivers like Britain's Mersey (have come to be referred to as) "the open sewer of the north-west" (Lean, 1986, p.21); (while) seas like the Baltic have been adjudged to be an "alarm clock of pollution for the whole world ..." (ibid,p.21).

2.2.3.3 Land pollution

Pollution of the land occurs as a result of the indiscriminate use of agricultural chemicals, the dumping of hazardous wastes, household and industrial garbage and, to a lesser extent, litter.

The greatest problem associated with the production and use of agricultural chemicals is that they are artificially manufactured, and as such are generally unsuited for sustained use in an ecologically sensitive natural environment.

Agricultural chemicals can basically be divided up into two distinct groups, namely fertilizers and biocides. Biocides can be further subdivided into three different categories, i.e. insecticides, fungicides and herbicides. Each biocide, as with all the different kinds of fertilizers, is manufactured to perform a specific function.

It must be appreciated that it is extremely difficult, if not impossible, to manufacture a poison which can destroy a specific insect, pest or plant without affecting other species, because of the complexity and interconnectedness of food chains and the sensitivity of ecosystems.

DDT (dichloro-diphenyl-tricholoro-ethane) is the most notorious and best documented example of how a once useful insecticide developed disastrous side-effects in the environment. The dangers of DDT were recognised only after 30 years, before it was finally banned in the USA, West Germany, France and Britain during the 1970's (Goldsmith and Hildyard, 1988, p.128). However, despite the ban, Myers points out that "the US still manufactures over 18 million kg a year for export, largely to the Third World" (Myers, 1985, p. 123). Agricultural chemicals, whether fertilizers or biocides may also get washed off crops and find their way into the water cycle via seepage into rivers, dams, subterranean water, oceans and seas, resulting in pollution of these sources.

The publication of toxic waste disasters such as the one at Love Canal in the U.S.A. in 1978 and Lekkerkerk in Holland in 1980, have caused many environmental groups to call for a total ban on the dumping of hazardous wastes. As countries, particularly in the industrialised world, begin to implement stricter controls on hazardous waste dumping in their own countries, sites in Third World countries are now being investigated. Gray (1988) confirms this by reporting that:

> "nearly a dozen African countries either have signed contracts to accept industrial wastes, are negotiating such contracts, or have been approached, according to interviews with government officials and representatives of the Nairobi-based United Nations Environment Programme" (The Argus, June 18, 1988).

South Africa has also been considered as "a major dumping ground for international toxic waste" (The Argus, July 6, 1989, p. 1). While the problems of agricultural chemical misuse and hazardous waste disposal are no doubt the main causes of land pollution, another growing problem is household waste and litter. This is especially true when considering the increasing number of non-biodegradable items, such as the array of plastic containers, wrappers and packages that combine to make up a high percentage of household garbage. In order to dispose of this waste it is taken to a central tip where it is dumped, gradually forming what Seymour and Girardet (1987) call a "fountainhead of pollution". Degradation of possible arable land, either by expanding rubbish dumps or soil erosion, are features of the environmental crisis which must not be allowed to proliferate.

2.2.4 Soil Erosion

Seymour and Girardet (1987, p. 40) suggest that soil erosion is the biggest cause of the environmental crisis, because they regard it "as the most serious threat to our planet at the present time".

Soil is a layer on the earth's surface which is, on average, approximately 60 to 250 cm deep, while the productive top-soil so necessary for crop cultivation is only about 25 cm thick over most of the earth. (Arvill, 1983, p. 30). It must also be noted that

> "not all the soil which covers the Earth's icefree land surface is suited for growing crops. In fact, of the total area of some 13 billion ha (about one quarter of the globe), a mere 11% presents no serious limitations to agriculture. The rest is either too dry, too wet, too poor in nutrients (mineral-stressed), too shallow or too cold".(Myers, 1985, p. 24).

Hence, it is of crucial importance that this very thin layer of soil is wisely used to prevent it from deteriorating in terms of quality and quantity. Despite the urgent need to conserve this resource, soil erosion has become an enormous problem world-wide. The loss of arable land due to soil erosion is possibly one of the most important factors contributing to growing poverty in the Third World.

2.2.5 **Poverty**

The high occurrence of poverty in the Third World is due to a combination of factors. These are some of the main aspects:

(a) the lack of land management skills and techniques;

(b) the unequal distribution of natural resources;

(c) burgeoning population growth-rates;

(d) wars;

(e) political instability and corruption;

(f) natural disasters such as prolonged droughts; and

(g) soil erosion.

Countries in the South are thus ironically, in their quest for higher standards of living, technology and wealth, increasing poverty-stricken conditions among the majority of their citizens by ignoring internationally accepted conservation and environmental strategies and principles.

Leaders of Third World countries might argue, in defence of these actions, that "struggling week by week to survive, the absolute poor have no time to worry about global environmental trends" (Lean, 1987, p. 44). They may also contend that the rich countries of the North should cut back on their over-consumption of the world's natural resources, so that the Third World can attain similar levels of development and industrialisation.

Although poverty could be seen as the direct cause of some environmental problems, it should first be recognised as constituting an environmental problem itself. Only when

Environmentalism

← Ecocentrism		Technocentrism →	
Deep environmentalists	**Self-reliance soft technologists**	**Accommodators**	**Cornucopians**

Deep environmentalists and Self-reliance soft technologists (shared):

1 Lack of faith in modern large-scale technology and its associated demands on elitist expertise, central state authority and inherently anti-democratic institutions

2 Implication that materialism for its own sake is wrong and that economic growth can be geared to providing for the basic needs for those below subsistence levels

Deep environmentalists:

3 Intrinsic importance of nature for the humanity of man

4 Ecological (and other natural) laws dictate human morality

5 Biorights—the right of endangered species or unique landscapes to remain unmolested

Self-reliance soft technologists:

3 Emphasis on smallness of scale and hence community identity in settlement, work and leisure

4 Integration of concepts of work and leisure through a process of personal and communal improvement

5 Importance of participation in community affairs, and of guarantees of the rights of minority interests. Participation seen both as a continuing education and political function

Accommodators:

1 Belief that economic growth and resource exploitation can continue assuming

(a) suitable economic adjustments to taxes, fees, etc.

(b) improvements in the legal rights to a minimum level of environmental quality

(c) compensation arrangements satisfactory to those who experience adverse environmental and/or social effects

2 Acceptance of new project appraisal techniques and decision review arrangements to allow for wider discussion or genuine search for consensus among representative groups of interested parties

3 Provision of effective environmental management agencies at national and local levels

Cornucopians:

1 Belief that man can always find a way out of any difficulties either politically, scientifically or technologically

2 Acceptance that pro-growth goals define the rationality of a project appraisal and of policy formulation

3 Optimistic about the ability of man to improve the lot of the world's people

4 Faith that scientific and technological expertise provides the basic foundation for advice on matters pertaining to economic growth, public health and safety

5 Suspicious of attempts to widen basis for participation and lengthen discussion in project appraisal and policy review

6 Belief that any impediments can be overcome given a will, ingenuity and sufficient resources arising out of wealth

Figure 2.1 The pattern of environmental ideologies (source O'Riordan as cited in Huckle (ed) Geographical Education: Reflection ad Action, 1983, p. 101.)

poverty is recognised as being part of the human-environmental crisis, can it begin to be resolved.

2.2.6 Ignorance and Dissension as to the Cause and Effect of Human Impact on the Environment

From the discussions above it might appear obvious that the world faces a human-environmental crisis. Southwick (1976), however, disagrees noting that many writers (Alder, 1973; Bettman, 1974; Cole et al, 1973; Kahn and Bruce-Briggs, 1972; McKetta, 1975; McPherson, 1975; (Southwick, 1976, p.366), suggest that ecologists and environmentalists are too pessimistic, and are simply "prognosticators of gloom and doom" (ibid, 1976, p. 367).

O'Riordan (1981) suggests that environmental ideologies can be located on a scale from ecocentrism at the one end to technocentrism at the other (see Figure 2.1). All these ideologies recognise that environmental problems do exist. However, they differ in how they should be solved. The technocentrists believe that problems can be solved through very little, if any socio-economic changes. They also believe that the answers to environmental problems lie in modern science and technology. On the other hand, the ecocentrists are idealistic and revolutionary in their approaches to solving the environmental problems of the world. They look beyond the actual environmental problems to the root causes. These they believe are due largely to the present political, economic and industrialised way of life in Western society. They therefore advocate a complete change in the present economic, political and social structures of this society.

The problems that emerge here are :

(a) that, although a World Conservation Strategy was developed in 1980 (taking regional and national differences into account), how to convince countries to implement it remains the challenge.

(b) how to solve the human-environmental crisis without changing the present Western world view.

2.2.6.1 The Western World View

The present Western world view has evolved over the past 400 years, and is still largely under the influence of logical positivism and the mechanistic Newtonian paradigm. Spretnak and Capra (1985) criticise this world view by pointing out that it

> "consists of a number of ideas and values, among them the belief in the universe as a mechanical system composed of elementary material building blocks, the view of the human body as a machine, the view of life in society as a competitive struggle for existence, the belief in unlimited material progress to be achieved through economic and technological growth, and - last, not least, - the belief that a society in which the female is everywhere subsumed under the male is one that follows a basic law of nature." (Spretnak and Capra, 1985, p. xvi).

This particular way of viewing the world which dominates or influences most countries of the world has been culturally transferred from generation to generation, with minor adjustments and modifications, and is referred to by Smith (1981) as the 'Modern Western Mind Set'.

The problem with criticising this world view is that one has to appreciate that it has been formulated over hundreds of years, it is not the only world view, and cannot simply be replaced immediately. Rifkin and Howard

(1985) emphasise that the success of a world view is measured by the fact that "it is so internalised from childhood on, that it goes unquestioned" (Rifkin and Howard, 1985, p. 15).

Bowers (1982) points out that the 'Modern Western Mind Set' as a mode of thinking is incapable of resolving the ecological crisis because it is basically a form of thinking that is abstract and theoretical with the emphasis on efficiency, industrial production and material gain. This world view is largely responsible for the human-environmental crisis.

There is therefore a need to replace or at least review, the present way of thinking to one which advocates a more ecologically-balanced approach to life. The world faces a number of possible choices for the future. Robertson (1983) offers five alternative scenarios:

(a) the Business-as-Usual option in which life carries on in much the same way as it always has;

(b) the Disaster option in which the world inevitably comes to a catastrophic end, because there is no way to solve the human-environmental crisis or its consequences;

(c) the Authoritarian Control option in which both left and right wing radicals believe that the way to solve the human-environmental crisis is by establishing authoritarian state governments.

(d) the Hyper-Expansionist Future option in which the present consequences of the human-environmental crisis can to be solved by science and technology; and

(e) the most emotional of all, the Sane, Human, Ecological Future option in which a revolutionary change is to be brought about in the present dominant world view. .

It is evident that the above proposed future scenarios correspond well with O'Riordan's (1981) range of environmental ideologies mentioned earlier.

Although some of these future options appear to be more idealistic than practical, Robertson (1983) makes the valuable observation that:

> "we need to understand all these different views because the actual future will almost certainly contain elements of all five : to some extent things will continue as before; to some extent there will be disasters; to some extent the enforcement of new regulations will be needed; to some extent people will develop new ways of living more sanely, more humanely, and more ecologically" (Robertson, 1983, p. 14).

So, ultimately part of the solution to the human-environmental crisis lies in changing people's views and understanding of the world. This, one hopes, will lead to an environment-friendly life style.

2.3 CONCLUSION

There is much evidence to support the view that Earth is facing a human-environmental crisis (Myers, 1985, p.18). Although most of the evidence cites European or American examples, the entire planet is affected. Africa and Southern Africa are no exception, and like many other regions which started to industrialise long after Europe and

North America, are showing many of the symptoms of the crisis elucidated above (Harrison, 1987, p.26 and Huntley, Siegfried and Sunter, 1989, p.11).

What is evident is the fact that people are directly responsible for the human-environmental crisis. As such, it can only be solved by people. The challenge of any solution lies in changing people's attitudes, knowledge and actions towards the total environment so that individual life styles can become more ecologically balanced and reasoned.

This researcher believes that it is largely through formal education that choices for the future can be thought about, discussed and eventually acted upon. The school, which is "a specialised social agency established to cultivate preferred skills, knowledge and values in the learner", tends to perpetuate the present Western world view (Gutek, 1974, p. 4) and needs to embrace a new approach in education in order to examine choices for the future. It is contended that Environmental Education is one such new approach.

CHAPTER THREE

ENVIRONMENTAL EDUCATION

3.1 INTRODUCTION

In order to appreciate the value of environmental education as a new approach in education, environmental education (EE) needs to be examined in terms of the following:

3.1.1 the origin and development of EE;
3.1.2 the definition of EE;
3.1.3 the tripartite nature of EE;
3.1.4 the aims and objectives of EE; and
3.1.5 EE's place in South African education.

3.1.1 The Origin and Development of Environmental Education

The philosophical roots of environmental education can be traced back to the earliest days of human history. While the earliest human societies lived a nomadic, hunter-gatherer existence, they did so in harmony with nature. They merely used what they needed, not upsetting the delicate balance of nature. They probably adopted this approach instinctively because their very survival depended upon it. Thus there was no real conscious effort to educate one another about the consequences of environmental degradation until the time of the ancient Greeks. According to Irwin (1984 p. 7) "although faint origins of education for care of the environment can be traced back to classical Greek times, most notably in the writings of Plato and Theophrastus, the modern concept of environmental education had its roots in nineteenth century Europe". The devastating effects of the Industrial Revolution such as the growth of urban slums, poverty and pollution from factories and coal-burning machines prompted reactions from concerned individuals in various disciplines. The three most important figures were, the sociologist Frederick LePlay, the philosopher-biologist Ernest Haekel, and the botanist Patrick Geddes.

LePlay believed that botany needed to be studied in order to be able to understand the make-up of society, while Haekel is regarded as the person who first introduced the term 'ecology'. Irwin (1984) recorded further that "the major figure of the nineteenth century, in terms of the actual practice of environmental education, was Patrick Geddes (1854-1933), a Scottish professor of botany and student of LePlay sociology" (ibid, 1984, p.7).

However, despite these encouraging beginnings, the first half of the 20th century witnessed a drop off effect in interest in environmental issues. This was probably brought about by preoccupation with the First and Second World Wars, and their disruptive after-effects. Environmental concerns were, however, not completely ignored during this period and the International Union for the Conservation of Nature and Natural Resources (IUCN) was formed in 1948. Awareness of an environmental crisis developed during the late 1950's and early 1960's, popularised and disseminated by the mass circulation ability of the media, especially with the advent of colour television in 1951 in the U.S.A. This was also the time during which the environmental cause was taken up and debated on North American and European university campuses, further facilitating recognition of environmental issues as being of national, as well as of international concern (Southwick, 1976, p.xv). When leading politicians such as U.S. president L.B. Johnson publicly recognised that there was an environmental crisis, this signified that environmental problems were to be taken seriously. President Johnson stated in 1965 that "pollution is now one of the most pervasive problems of our society, [and] ... our present efforts in managing pollution are barely enough to stay even, surely not enough to make the improvements that are needed" (ibid, 1976, p. xviii).

Official governmental recognition of the seriousness of the state of the environment no doubt contributed to the inception of the idea that there was a need for environmental education. Disinger (1981) cites 1970 as the year in which EE was first officially recognised in the U.S.A. Soon after this date the United Nations (UN) took the lead in trying to promote and develop this new approach internationally within education. In 1972 the UN organised a conference on the Human Environment in Stockholm with the express purpose of making international organisations aware of the environmental crisis and the need for "education to focus its resources on this situation" (Diepeveen, 1983, p. 13). Following on this conference, two UN agencies namely, the United Nations Educational Scientific and Cultural Organisation (UNESCO) and the United Nations Environmental Programme (UNEP) were jointly set the task of promoting environmental education internationally. The three year plan which they devised culminated in a meeting on environmental education in Belgarde, Yugoslavia in October, 1975. This gathering of some 96 participants from 60 different countries was held in the form of a workshop. Its two main aims were:

> "(1) to review and discuss the trends and emerging issues in environmental education, and (2) to formulate, on this basis, guidelines and recommendations for furthering environmental education internationally" (Connect in Hughes-Evans 1977, p. 71).

These aims were realised, with the discussions leading to the establishment of international guidelines for environmental education, known as the Belgrade Charter.

The key prescriptions contained in the Charter are listed as follows:

"1. Environmental education should consider the environment in its totality - natural and man-made, ecological, political, economic, technological, social, legislative, cultural and aesthetic.

2. Environmental education should be a continuous life-long process, both in-school and out-of-school.

3. Environmental education should be interdisciplinary in its approach.

4. Environmental education should emphasise active participation in preventing and solving environmental problems.

5. Environmental education should examine major environmental issues from a world point of view, while paying due regard to regional differences.

6. Environmental education should focus on current and future environmental situations.

7. Environmental education should examine all development and growth from an environmental perspective.

8. Environmental education should promote the value and necessity of local, national and international co-operation in the solution of environmental problems" (Robottom, 1987, p. 88).

Robottom (1987, p. 89) viewed the charter "as an influential policy statement in the environmental education movement".

In 1977 UNESCO sponsored another international conference on environmental education which was held at Tbilisi in the U.S.S.R. The main purpose of this conference was to evaluate the progress which had been made in environmental education programmes since the Stockholm meeting in 1972. There appears to have been some success in that Diepeveen (1983, p. 12) notes that "by late 1977 more than thirty countries had formally promoted environmental education as an element of their education systems".

However, Jun-yi (1978, p. 36) points out that "since 1975, environmental education programs coming out from the UN conferences and workshops have appeared very much Western orientated and abstract in content".

Similar problems of Western bias and too much rhetoric also emerged during the "Tbilisi 10" conference held in Moscow in 1987. Annette Greenall (immediate past-president of the Australian Association of EE) together with some of the Australian delegates found the conference "frustrating because the Congress made no attempt to achieve its major objective" (Greenall, 1987, p.3). The major objective of "Tbilisi 10" was to review progress since Tibilisi 1977 and plan EE stategies for the 1990's.

It would be fair to say that since the inception of the term Environmental Education in 1970, attempts have been made internationally to promote EE and to develop EE programmes. However, fundamental problems still exist, namely confusion with conservation education, and EE being based on a Western and largely 1st World view of the world. EE needs to be defined and accepted by all nations as a separate, holistic and globally relevant educational process before it can be implemented with any hope of success.

3.1.2 **The Definition of Environmental Education**

For many years environmental education has come to mean different things to different people for different reasons. This point is clearly expressed by Irwin (1981, pp. 8-9) who states that:

> "environmental education has, amongst other things, been described as a 'goal of education' (NAEE, 1976, 'a process' (Bennett, 1973), 'a subject' (Carson, 1973), 'a field of study' (Martin and Turner, 1972), 'a medium for skill development' (Watts, 1969; Schools council, 1972b; Reid, 1974; Sandford, 1981), 'a way of life' (Selby, 1970), 'a style of education' (Carson, 1978; Pederson, 1981) and the 'key to the future' (Hughes-Evans, 1977)."

A statement made by Matthew J. Brennan (a so-called founding father of environmental education) in 1979 provides some insight into understanding why this state of uncertainty and confusion exists in defining EE. Brennan is reported to have expressed

> "regret for his role in replacing the term 'conservation education' with 'environmental education' because the change apparently clouded recognition of what needed, and needs to be done" (quoted in Disinger, 1981, p. 12).

It is thus apparent that the term EE is often confused with that of conservation education (CE). The problem with this interpretation is twofold:

(a) Both terms developed in response to a specific set of circumstances. Conservation education developed as a means of instruction to ensure the survival of plant and animal species and the protection of their natural habitats. EE came into existence as a direct response to the global human-environmental crisis;

(b) Conservation ("protection, preservation, and careful management of natural resources", Collins Dictionary, 1986, p. 182) and conservation education ("instruction in the wise use of resources", Clayton, 1981, p. 33) by their very nature imply a continuation of the existing socio-economic and political status quo. While EE by its very definition recognizes that people are inextricably linked with the natural environment and therefore whatever humans do has a certain impact on the total environment.

In essence then, EE directly challenges the existing way of life, calling for a re-examination and the possible introduction of radical changes to the status quo.

Thus the critical difference between EE and CE appears to be an ideological one in that the former has an all-encompassing social, economic, political and ecological basis, while CE covers only the economic (in the narrowest sense, i.e. supporting the principles of free enterprise) and ecological spheres. This viewpoint can be disputed by the fact that "in the USSR a commitment to environmental conservation was written into the constitution" (Irwin, 1984, p.7).

The above distinctions also help one to understand why (in trying to define EE) the words "environment" and "education" have also come to mean different things to different people. The broadest interpretation of environment seems to refer to the total natural surroundings. However, this has been criticised when used in connection with an understanding of environmental education. Irwin (1983), for instance, points out that "some writers such as Wheeler (1970, 1975, 1976), Martin (1969a, 1973, 1975) and Carson (1973, 1977, 1978, 1980) have consistently stressed the need for the concept 'environment' to move away from being equated merely with its 'natural' component, and to include the built or man-made environment" (Irwin, 1983, p. 7). Expanding upon this view, Huckle (1986a) and Di Chiro (1987) have recently introduced a 'new' interpretation of the term 'environment'. Both refer to the fact that this term has been socially constructed (Huckle, 1986a and Di Chiro, 1987). Di Chiro (1987, p. 11) explains that

> "the idea that 'environment' is socially constructed suggests the same for the conceptualisation of 'environmental problem'. Environmental problems (e.g. malnutrition and poverty) are therefore, social problems caused by societal practices and structures ...".

The term 'environment' thus refers to everything that surrounds us both physically and socially. This means in effect that an interpretation of 'environment', in terms of EE, must include the political, social, economic and natural environments (i.e. a holistic view of what must be seen as the total environment).

The word 'education' has also come to be understood and interpreted in different ways. Hughes, (1959), Gutek, (1974) and Straughan and Wilson, (1983), all agree that the term 'education' can be viewed in two specific ways: firstly, as a broad process which takes into consideration all the influences that the social and natural environments have upon the individual; and, secondly, that which takes place in an educational institution, such as a school. Huckle (1986, p. 14) sees schools as "essentially conservative institutions which serve to reproduce society as it is. By conveying skills and beliefs which support the economic and cultural status quo ...".

Although schools may be regarded as inherently conservative institutions, not all of the people who work and learn in them (pupils and teachers) are necessarily conservative. Huckle (1986a, p. 14) acknowledges this:

> "There is space within schools to challenge social reproduction by developing pupils' social literacy. This is to be done by teaching appropriate knowledge, skills and attitudes which can help young people to read and write about their social situation and become active and critical citizens capable of sustaining a democracy and working for a better world".

According to these ideological differences, EE can be viewed in three ways:

(a) Education about the environment refers to the environment being made the subject of academic study. It is thus hoped that by studying the environment (in the classroom) will create an understanding of environmental issues, and promote sound environmental management principles among pupils.

(b) Education from (or in) the environment refers to the actual use of the environment as a medium for education. This form of education could possibly be seen to concentrate on an aesthetic appreciation of nature and the natural environment, rather than deal with socio-political factors. Education *in* the environment might thus be said to reflect the idealism of the ideology of utopian environmentalism.

(c) Education for the environment has, as its basic goal, the well-being of the environment. Pupils are exposed to environmental issue-based learning activities which, it is hoped, will increase their environmental knowledge, skills and attitudes, in order to help them form their own judgements, and take action on environmental issues.

However, Huckle (1983, p. 106) argues that

> "all three forms of environmental education lead to claims that education promotes environmental quality, but only if there is adequate attention to education for the environment may such claims be thoroughly justified."

These discussions and debates have led to many definitions of EE being put forward "but one of the earliest, and today by far the most widely accepted is what is known as the IUCN (International Union for the Conservation of Nature and Natural resources)" (Irwin, 1990, p.5). The definition states that

> "Environmental education is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulating of a code of behaviour about issues concerning environmental quality" (Carson, 1978, p. viii).

Irwin (1988) suggests that the reason for the IUCN definition being more widely accepted internationally and locally (i.e. in Southern Africa) is because

> "it embraces what many, if not most, 'environmental educators' regard as the essential elements of the concept i.e.
>
> - the inter-relatedness of people, their culture and the biophysical surroundings
> - that people hold values and attitudes which inter alia relate to the environment and to behaviour towards the environment
> - that 'skills', including decision-making and the formulation of norms are an integral aspect." (Irwin, 1988, p. 1)

Despite the apparent unanimity with regard to the IUCN definition, many 'third world' countries have criticised this interpretation of EE, because it does not deal with what they consider to be the real issues (i.e. poverty, strife and death occurring among their people). This view was highlighted by Irwin (1988) who noted O'Riordan's (1981a) exposition of EE which states that

> "behind all the reasoning is the spectre that any attempt at continued growth in its current wasteful and highly inegalitarian form will not only result in very real and imminent resource scarcities, but will necessarily lead to environmental destruction and serious poverty and social hardships. The worst consequences will fall disproportionately upon those who are least able to help themselves, and whose indigenous abilities to cope with resource scarcities and environmental stress are already being eroded by

> forces mostly beyond their control, and whose voices in the halls of political power are either not heard at all or are extremely faint." (in Irwin, 1988, pp. 2-3).

It is evident from the above, that it is possibly more realistic to move away from the idea of one universally acceptable definition to a broader more representative interpretation of EE. This would require that EE be viewed holistically (i.e. ecologically, socially, economically and politically).

3.1.3 The Tripartite Nature Of Environmental Education

Environmental Education is an integral part of the educational process, however it is characterised by it's holistic approach which is made up of cognitive, affective and conative or action components (Greenall, 1986 p. 11). Therefore the main elements of Environmental Education can be described as follows:

> "the inter relatedness of people, their culture and their biophysical surroundings;
>
> that people hold values and attitudes which inter alia relate to the environment and to behaviour towards the environment;
>
> that "skills", including decision-making and the formulation of norms, are an integral aspect" (Irwin, 1990, p.5).

Given the tripartite nature of EE "the key to the achievement of the goals and objectives of environmental education lies in the recognition of the contribution it can make to the development of our future citizens through their schooling" (Greenall, 1986, p.11).

3.1.4 The Aims and Objectives of Environmental Education

Before discussing the aims and objectives of EE, it is necessary to clarify these terms. 'Aims' generally refer to the intention, purpose or goal towards which something is directed (Collins Dictionary, 1986, p. 17), whereas 'objectives' are seen as being more tangible, measurable or in fact relating to a goal or aim (ibid, 1986, p. 580). Objectives may thus be said to be the means by which one intends to achieve one's aims. The major goal (or aim) of EE is seen as the need

> "to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skill, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones" (Connect, 1976, p. 70).

All the nations of the world should make an attempt to adhere to the following objectives of EE in order to achieve this global goal:

(a) to develop an awareness of the environment's susceptibility to human impact;

(b) to acquire knowledge about the environment;

(c) to develop attitudes of concern and care for the environment;

(d) to develop environmental problem-solving skills;

(e) to develop evaluation strategies in order to counter environmental problems; and

(f) to encourage participation and action in helping to solve these problems.

The aims and objectives of EE are indeed worthy, but they can be seen as being too generalised, in that they do not appear to take the various regional, national and local differences into consideration. This leads one to expect that implementation of the aims and objectives of EE, as part of a global strategy would encounter some difficulties, specifically within different countries and regions.

The misunderstandings and differences of interpretation which still exist with regard to EE could be possibly overcome if all the countries of the world recognise:

(a) the global seriousness of the human-environmental crisis;

(b) that it is each country's responsibility (whether East, West, developed or less developed) to try and solve the crisis as part of a joint and mutually beneficial global strategy;

(c) that the aims and objectives of EE need to form the basis of any such strategy aimed at dealing with environmental problems; and

(d) that these aims and objectives need to be understood in terms of the international environmentalist slogan "Think Globally but Act Locally" (i.e. modifying them to accommodate regional, national or local differences).

Having discussed the international implications and importance of EE it would now be appropriate to examine EE's position in South African education.

3.1.5 Environmental Education's Position in South African Education

3.1.5.1 Introduction

Before the position of EE in South Africa can be analysed, some insight into the country's educational system and philosophy upon which this education is based needs to be scrutinised.

3.1.5.2 A Brief Overview of the Education System in South Africa

South Africa's education system is inextricably tied up with the aims and objectives of the ruling Nationalist Party (which has been in power since 1948). Thus, as Robertson explains (1973, p. 3), "the South African government considers its prime duty to be the preservation of a society moulded in terms of an ideology comprising two basic inter-related elements - apartheid (segregation) and baaskap (white domination)". This ideology is further perpetuated through education, based on the policy of Christian National Education which had its beginnings as early as 1902 (Davenport, 1978, p.228). This has subsequently led to the official segregation of education in South Africa into four distinct groups: namely, Whites, 'Coloureds', Asians and Blacks, each with their respective education ministers and departments.

The implications of this educational policy for South Africa are as follows:-

(a) white education has enjoyed preferential treatment since 1948, i.e. more money being allocated to this sector of education than to the others, enabling the acquisition of better academic and sporting equipment, facilities and staff;

(b) four separate education systems were created with vast disparities existing between them, in terms of financial support, academic standards, suitably qualified staff, etc.;

(c) an opportunity to develop a common South African identity has been seriously hampered, delaying one non-racial education system for all;

(d) the various racial groups remain largely ignorant of how each other live and what their wants and needs are, although they live in the same country.

The only common features to emerge from the four systems appears to be that they all fall under the banner of Government education, follow government-designed syllabi, and that they are generally grounded in the more traditional educational philosophies which were brought into South Africa as a result of the early Dutch and British settlement of this country during the 17th and 18th centuries.

It can be assumed, therefore, that the general aim of education in South Africa is to maintain the present political, social and economic status quo. In order to achieve this, education in schools is largely based on rote learning, subject-matter disciplines, and textbook authority of the traditional educational philosophies.

These are no doubt broad generalizations, and cognizance is taken of individual teachers, principals and some independent schools who are more open-minded about education in general and the present educational dispensation. However, there are still a majority within the teaching profession, who willingly or unconsciously continue to support this approach to education and the education system. If this situation is accepted as being representative of formal secondary education within South Africa, then it must be contended that as such, the aims and objectives of environmental education will not be realized in this country until drastic educational changes are made.

The prospect of a 'new' South Africa appears to be closer since Mr F.W. de Klerk's 2 February 1990 speech, however, the establishment of one education system for all will take some time before being implemented. Therefore, education in its present form in South Africa (which is not entirely compatible with the aims and objectives of EE) will continue for some time yet. Together with the substitution of environmental conservation (or conservation education) for EE, it is understandable that the various Education Departments have had little success in promoting EE in their secondary schools.

Ideally therefore, for EE to be successfully integrated into the South African education system a more contemporary and compatible educational philosophy will have to be found and adhered to.

3.1.5.3 Educational Philosophies and Environmental Education

The more traditional educational philosophies (such as Idealism, Realism, Pragmatism, Perennialism, Essentialism and Thomism) would appear at the outset to have little affinity with environmental education, because of their ancient beginnings (historically-speaking for example Idealism can trace its origins back to c. 427 - 347 B.C.).

Gutek (1974, p. 8) refutes the above and points out that although traditional educational ideas and wisdom "have had a long history in Western civilization they are still vital philosophies that guide educational processes and give substance to various forms of curricula design".

Fuggle (1982 p. 2) also supports the notion that traditional educational philosophies still have educational value today, by pointing out that "Idealism contributes little to teaching methods but provides an aim for education, namely self-realization or the development of the highest potentialities of personality for all". As mentioned earlier, EE can also trace its origins to ancient Grecian times.

It is indeed ignorant to imagine that early educational philosophies will ever cease to influence didactic thought, planning and design. Perhaps the most important issue here is to find an EE-compatible philosophy. This philosophy would be required to change people's attitudes and actions towards the environment. For instance people must be able to examine, criticize and modify (if necessary) their existing attitudes and values. The traditional educational philosophies (in the opinion of the researcher) cannot be considered, because they have played such a part in helping to shape and establish the Western world view, which in turn has contributed to the present human-environmental crisis.

Thus, it is suggested that an educational philosophy compatible with EE should be sought in the following recent educational philosophies :

(a) John Dewey's Experimentalist Pragmatism;

(b) Progressivism;

(c) Reconstructionism;

(d) Existentialism; or

(e) Philosophical Analysis.

Ozmon and Craver (1981) point out that "Dewey saw education as an instrument for changing both man and society, and particularly in the 1920's and 1930's, this philosophy became identified in the minds of many people with radical social reform" (Ozmon and Craver, 1981, pp. 123-124). The turn of the century also saw the development of another educational movement in the USA, namely, Progressivism. Progressive educators claimed that they "had rebelled against what they called the excessive formation of traditional education, with its emphasis on strict discipline, passive learning and pointless drill" (Kneller, 1964, p. 94). They also set out to promote an alternative approach to curricula design and organization, which was child-centred, and relied on the use of a number of different teaching methodologies such as problem-solving techniques, outdoor activities and the project method.

It is thus suggested that a number of the innovations brought about by Dewey's pragmatism and progressive educators alike appear to be compatible with some of the aims and objectives of EE. This is also true of the educational philosophy known as Existentialism and the contemporary movement in educational philosophy referred to as Philosophical Analysis which both have threads running through them which could be deemed compatible with EE. Bigge (1982, p. 140) describes the Existentialist educators as:

> "committed to development of the choice making powers of individuals. Thus their emphasis moves away from the physical and social sciences and turns more to the humanities and arts, where man's aesthetic, emotional and moral proclivities are more exercised".

However, Gruber (1973, p. 241) challenges the success rate of existentialism in practice by stating that "although existentialism is a frequent topic of discussion in educational circles, actual applications of existentialism to the practice of public education are limited". A possible example of existentialism operating in education is A.S. Neill's Summerhill School in Suffolk, England, but his particular brand of 'freedom' education does not appear to be holistic in terms of linking people's actions to the environment (natural and human-made). Rather it seems to concentrate on individuals and their total freedom, without any apparent connection between individuals and their impact upon the natural environment.

Turning to philosophical analysis, Gutek (1974, p. 230) hastens to point out that although "philosophical analysis is a new method of working with language and of trying to clarify and establish its meaning, it does not attempt to create new philosophical systems or world views that embrace all of man's experiences".

From the above it is clear that none of the above educational philosophies are totally compatible with the aims and objectives of EE. This, therefore, leaves reconstructionism to be examined for its compatibility with EE.

At the outset, the educational philosophy of Reconstructionism appears to be compatible with the aims and objectives of EE.. This is supported by the fact that reconstructionists recognize that the world is at present facing a human-environmental crisis with the following symptoms :

(a) obvious national and international imbalances between wealth and poverty;

(b) problems of continued and ongoing conflict and war;

(c) environmental pollution;

(d) population explosion; and

(e) an age of possible thermonuclear destruction - possibly being the greatest threat to human existence ever.

Reconstructionists, in identifying that society is in need of change, believe that education is the means of bringing about this new social order.

In order to bring about this new society Reconstructionists therefore believe that pupils should be able to "detect the beliefs, customs, and institutions that impede cultural renewal. Those values that dominate merely because they are customary, must be discarded" (Gutek, 1974, p. 165).

However, because reconstructionists believe that educational philosophies, and therefore education, are "products of their age and are contextual to given cultural environments" (Gutek, 1974, p. 164), they believe that education itself will have to be reconstructed. Consequently, school curricula, teaching methods, educational administration and the training of teachers will have to be adjusted or changed so as to be able to lead young people in programmes of social reform and change.

Ozmon and Craver (1981) note that

> "while reconstructionist theories are not always accepted, they can stimulate and provoke thinking about critical issues. They have [also] provided visions of a more perfect world and have suggested means of attaining them. It is, perhaps, a shortcoming of their philosophies that they do not have future goals, either short-range or long-range."

There do appear to be many areas of overlap between reconstructionist philosophy and the aims and objectives of EE, and therefore it could form the basis for the promotion of EE. However, there is one important omission. Although reconstructionists recognize both aspects of the human environmental crisis, they do not seem to appreciate the fundamental interdependence and interconnectedness of the two components.

Thus it is with this particular background that the incorporation of EE into South African education must be understood.

3.1.5.4 The Incorporation of Environmental Education into the South African Education System

In considering the incorporation of environmental education into the South African education system, it should be noted that the IUCN definition "is widely regarded as a useful working definition and is encapsulated in the 1989 South African White Paper on Environmental Education" (Irwin, 1990, p.5).

Concern about the natural environment and its protection in South Africa can be traced back to the late 19th century when President Paul Kruger set aside land for the development of a wildlife sanctuary - the internationally famous Kruger National Park. Fuggle (1983) adds that it is also

> "salutary to recognise that South Africa's recognition ofnature conservation as a public responsibility dates from the National Parks Act 56 of 1926, and that provincial nature conservation Ordinances are as recent as 1947 for the Transvaal and Natal, 1952 for the Cape and 1969 for the Orange Free State" (Fuggle, 1983, p. 484).

On the part of voluntary organisations Schweizer and Cooper (1983) observe that "the first conservation societies, known as Game Protection Associations (GPA), were established at the end of the nineteenth century ..." (ibid, 1983, p. 134). The most notable voluntary nature conservation organisation is undoubtedly the Wildlife Society of Southern Africa founded in 1926, which is still in operation with branches throughout South Africa today.

However, a notable omission from this scenario is the absence of the simultaneous development or establishment of environmental pressure groups such as Greenpeace and Friends of the Earth (apart from Earthlife Africa, founded very recently in 1989). Similarly political parties with ecological bases, such as the Green Party or Ecology Party in West Germany and Britain respectively, have not fully emerged either.

The reason for this situation in South Africa could possibly be explained as follows:

(a) The majority of people in this country do not regard environmental issues as being political issues or a political priority;

(b) Nature Conservation organisations and the Government generally in the past tended to regard environmental issues as non-political in nature, i.e. divorced from the economic, political and social 'status quo'.

Despite these shortcomings non-governmental conservation groups were the first to co-ordinate their actions during the 1970's in order to press government into giving statutory recognition to nature conservation.

The South African Nature Foundation (SANF) was established in 1968. The specific aims of the SANF are "to assist in nature conservation in all its forms, to educate the public, and to raise and distribute funds for conservation projects throughout Southern Africa" (ibid, 1983, p. 137). The SANF is also the representative for the World Wildlife Fund (WWF) in Southern Africa, thereby keeping the nature conservation lobby in South Africa abreast of and in touch with international conservation developments.

The 'Council for the Habitat' another voluntary organisation, was formed in 1972. It was later known as the Habitat Council and served as the national co-ordinating body for all the conservation organisations in South Africa.

Hurry (1982) maintains that the Wildlife Society of Southern Africa (WLS) should be recognised as one of the early motivators of conservation education in South Africa. Proof of this was the organisation of an international symposium on conservation education in South Africa in 1976 by the WLS, which then followed the symposium with a national survey dealing with various aspects of conservation education during 1977 - 1978. The WLS explained that the results of its survey indicated the need for environmental conservation to be incorporated into the existing education system in South Africa.

The concerted efforts of these organisations, particularly those of the WLS, no doubt contributed to the government tabling a White Paper on a proposed National Policy for Environmental Conservation in 1980. The eleven most important points contained within the White Paper, according to Hurry (1987, p. 6), "could just as well have been written as objectives for a national environmental education curriculum". The points do not, however, promote environmental education, but rather what has been referred to as environmental conservation (EC). This supports the view that EE in South Africa is regarded as being synonymous with conservation education or enviromental conservation.

Government then recognised the importance of the White Paper by appointing a commission of inquiry in 1982 specifically to investigate its proposals. The findings of the commission formed the basis of what became the Environmental Conservation Act in 1982. Rabie and Erasmus (1983, p. 36) comment that

> "it was stated in Parliament that it [the Environmental Conservation Act] is probably the most important conservation measure to be adopted in South Africa since the Second World War ....".

The Act's main function is to control any actions which might affect the environment or the conservation of it. However, the Act also provides for the appointment of environmental conservation officers, financial support for approved conservation activities, the encouragement of teachers to incorporate environmental conservation in their teaching and also creates the opportunity for the setting up of auxiliary committees to help carry out its functions. The two committees which emerged were, the Council for the Environment formed in 1984 and the Committee for Environmental Education created by the former Council in 1985. The Council for the Environment's main task was to advise the Government on all aspects of environmental management while the Committee for Environmental Education was set up to help individuals and organisations involved in environmental education, or rather conservation education.

The State President on behalf of the Government also instructed the President's Council's Planning Committee in 1982

> "to investigate the report on : (a) The principles by which priorities between development and conservation can be determined ... [and] (b) The position of nature conservation in South Africa, including national parks and the preservation of the country's natural heritage for posterity against the background of international norms as well as those systems that still have to be preserved and the financing of projects in the field of conservation" (ibid, 1983, p. 117).

These were all positive attempts to show that nature conservation issues were of national importance. In April 1982, possibly influenced by international EE events, an international conference on environmental education was held at Treverton College in Mooi River. This subsequently led to the establishment, in September 1982, of the Environmental Education Association of Southern Africa (EEASA) by a number of educationists and conservationists. EEASA recognises the IUCN definition of environmental education and subscribes to the aims, objectives and guiding principles as laid down at the Belgrade Conference (1975) and later revised at the Tbilisi conference in 1977. The five main objectives of EEASA are:-

"(a) To act as a responsible body for the purpose of consultation and coordination on matters of public and professional interest concerning environmental education;

(b) To promote inter-disciplinary as well as multi-disciplinary studies of the environment;

(c) To promote, organise and sponsor activities and research in environmental education;

(d) To disseminate information pertaining to environmental education; and

(e) To provide opportunities, inter alia, by means of regular publications, for the exchange of ideas and opinions" (EEASA newsletter, Vol. 3 No. 1, 1984, p. 2).

EEASA immediately tried to achieve these objectives (or at least some of them) when it submitted a set of proposals to the Planning Committee of the President's Council in June 1983, suggesting that environmental education be integrated into all existing curricula. The Cape Education Department had, in March 1983, drawn up and made available to teachers a guide: "Teaching for Environmental Conservation" (later updated by Hurry on behalf of the Committee for Environmental Education of the Council for the Environment in 1987 which stressed that "some existing syllabuses already contain a great deal of direct or implied environmental content ... [and] there is no subject which does not lend itself to an environmental education approach" (Diepeveen, 1983, p. 48). Possibly the launch of this guide for teachers should have coincided with a series of workshops for teachers on environmental education.

In 1984 the Council for the Environment held a workshop at the Midmar Dam to try and formulate a national policy on environmental education. It was attended by 42 participants from various government and non-government organisations.

The main points of interest to emerge from this workshop were:

(a) that the Council for the Environment was recognised as the most appropriate body to promote EE;

(b) that greater emphasis should be placed on education and its specific role in disseminating EE, not as a separate subject but rather as an environmental process;

(c) that the need for extensive research into teaching methods and EE programmes be recognised;

(d) that it should become a priority to ascertain the present attitudes and needs of all South Africa's people with regard to environmental issues. This, it was decided was crucial if attitudes towards the environment were to be changed in South Africa;

(e) that teachers generally needed to undergo in-service training in EE, and that teachers and teacher-trainers needed to be the first people to be encouraged to promote EE;

(f) that financial incentives and possibly tax rebates should be created for organisations offering accredited EE programmes; and

(g) that television and radio should be explored as media for promoting EE.

The success of the Midmar conference can be measured in terms of the Government's publication of a White Paper on Environmental Education, which was approved by the Cabinet and tabled in Parliament in mid-1989. The aim of the document is stated as follows:

"This White Paper formulates the objectives of environmental education for the promotion of actions at all government levels, including all formal education authorities and individuals and institutions concerned with non-formal and informal education" (White Paper, 1989, p. 5).

Allied with this is the new Environment Conservation Act which was approved by Parliament at the end of May 1989.

However, despite these advances in the name of EE in South Africa, the environmental education movement is partially flawed by the fact that it still adheres to an apolitical conservation education idealogy.

Irwin (1990) would dispute the above viewpoint by indicating that the South African environmental situation has been changed by a 'realconserve' perspective " - the idea that in order to place environmental education in its logical context it must be realised that the task cannot be reduced to problems of industrial hygiene and the connservation of species, even though these are important. The real issues to be dealt with are those causing day-to-day hardship and the death of people all over the world" (Irwin, 1990, p.22).

Thus it is important to note that the former viewpoint tends to favour the less controversial cognitive and skill aspects of EE, while neutralising the more controversial and yet vital political and moral ones. This sentiment is also supported by Greenall (1981, p. 292) who declares that

"as long as such action is countenanced, as it certainly is at present, by the Australian education authorities (who although professing a strong belief in environmental education are loath to stress its moral and political components), then the introduction of environmental education in its full meaning into schools will be negligible".

It is thus clear that before effective programmes in EE can be set up in South Africa the above view and political position will need to be changed so that:

(a) it can be generally accepted by the majority of people in the country;

(b) it is realised that conservation education (or environmental conservation) is but a part of the holistic, interdisciplinary and ecologically-based educational process known as environmental education (Figure 3.1).

(c) EE's focus includes the various human and socio-political aspects stressing that it is education <u>for</u> the environment.

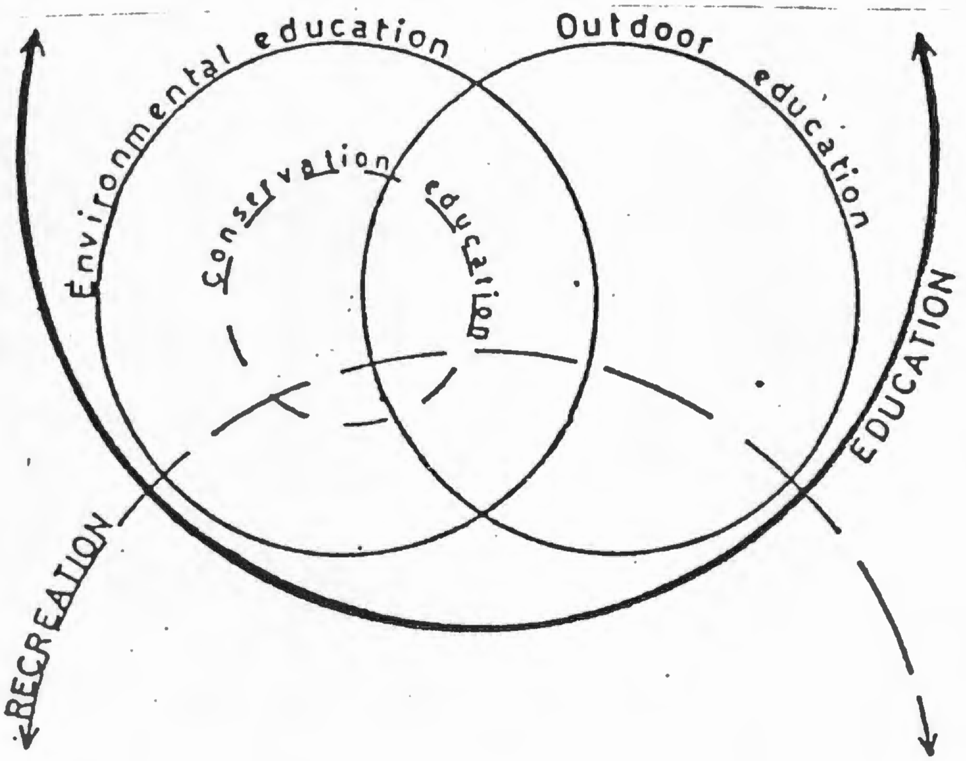

Figure 3.1 DIAGRAMMATIC MODEL ILLUSTRATING THE RELATIONSHIP OF ENVIRONMENTAL EDUCATION TO OTHER FIELDS OF EDUCATION AND TO RECREATION (Irwin, P.R., 1983, p. 18).

3.2 CONCLUSION

It is clear that EE initially developed as a response to the human-environmental crisis. However, because EE originated in Europe (a Western, 'first world', industrialised region), most of the early definitions or interpretations of EE tend to reflect this world view. This also helps to explain the development of EE in South Africa.

Despite all the problems associated with EE, particularly in South Africa, it is indeed important to try and prevent EE from being neutralised within the existing hegemony and educational milieu within this country by developing a teaching strategy which is based on reconstructionist philosophy and is also appropriate and relevant for South Africa in the 1990's and beyond.

CHAPTER FOUR

A TEACHING TECHNIQUE FOR ENVIRONMENTAL EDUCATION IN SOUTH AFRICA

4.1 INTRODUCTION

The development of a teaching technique for EE (which could be based on Reconstructionist philosophy) which expects pupils to be able to deal with attitudes and values as well as knowledge and concepts, demands more than a rote learning approach. Such an approach involves values education. The particular teaching technique from this educational approach which appears to be compatible with EE is the simulation method.

4.1.1 Values Education

Values or moral education can be described as an educational approach which "enables pupils to derive, clarify and apply values in such a way as to counter confusion, guide choice and contribute to the solution of problems" (Huckle, 1981, p. 149).

This means that pupils are given the opportunity to reach their own conclusions with regard to understanding social issues, by using not only knowledge pertaining to each issue, but also attitudes and values. It appears that values education is compatible with the aims and objectives of education for the environment. However, to gain a clearer understanding of the compatibility of EE and values education, it is necessary first to examine the concepts : attitudes, beliefs and values, which are central to values education.

Allport (1971) after examining a representative sample of definitions and characterisations of attitudes observed that a common thread ran through them all. He noted that "in one way or another each regards the essential feature of attitude as a preparation or readiness for response. The attitude is incipient and preparatory rather than overt and consummatory. It is not behaviour, but the precondition of behaviour" (Allport, 1971, p.18). He therefore defined an attitude as "a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" (ibid, 1971, p.19).

The Collins Dictionary defines a belief as "a principle, etc., accepted as true or real, especially without proof" (Collins Dictionary, 1986, p.72). The term 'value' is often the most difficult to define, because it is regarded as being synonymous with attitudes and beliefs.

Maye (1985) agreeing that while it is difficult to define a notion such as a value, indicates that several characteristics pertaining to them can be identified. These characteristics are as follows:

"(1) Values are abstract concepts people hold about what is important in relation to aspects of life experience.

(2) Values are closely related to actions and behaviour people engage in.

(3) Values are often labelled by abstract terms.

(4) Values give rise to value judgements, value differences and value conflicts.

(5) Value differences occur between individuals and groups" (Maye, 1985, p.33).

However, although attitudes, beliefs and values are closely related concepts, there are distinct differences between them. Huckle (1981) distinguishes between the three concepts in the following way:

(a) Values are seen as individual, long-lasting beliefs which are regarded as moral truths by the individual;

(b) Attitudes are regarded as being a mental view or disposition towards a situation or object, in terms of positive or negative feelings; and

(c) Beliefs are viewed as assumptions about life which individuals think are true or real without first being proven.

The importance of these concepts for EE is highlighted by Boardman (1986, p. 63) who believes that

> "people's viewpoints, opinions and deeply held values influence the way they react to environmental matters, the way they make decisions about the environment, and the way they take action."

Huckle (1981) believes that an individual's behaviour is influenced, if not shaped by one's values, attitudes and beliefs. Clacherty (1988) referring to Reich and Adcock (1976), Rosenberg (1967) and particularly to Fishbein (1967c) notes hesitantly "that one cannot assume that changing a person's attitudes will result in changed behaviour (Clacherty, 1988, p.33). He goes on to qualify this statement by stating that if an attitude is changed it may or may not lead to changed behaviour.

Thomas (1971) concludes that "most theorists who treat attitudes as affect still consider that they are, amongst other factors, determinants of behaviour" (Thomas, 1971, p.11). However, he adds that "although it is theoretically possible to demonstrate attitude change followed in time by behaviour change, thus implying a causal relationship, the reverse is not true. This is because overt behaviour is, by definition, observed or measured as it occurs whereas the exact time of attitude change is not revealed simply by its measurement, indeed it cannot be denoted" (ibid, 1971, p.11).

When dealing with the connection between behaviour and attitudes, it is essential to take into consideration all the possible variables in order to gain a balanced perspective. It is therefore "clear that" an understanding of attitudes and values, how they are formed, how they are changed, and how they relate to behaviour, is thus vital to Environmental Education" (Clacherty, 1988, p.35). It is also important to consider the above when preparing a teaching strategy for values education.

4.1.2 Teaching Strategies for Values Education

Table 4.1 shows the various teaching strategies for values education as suggested by the following authors (Maye, 1985; Fien and Slater, 1981; and Huckle, 1981).

TABLE 4.1 : Teaching Strategies for Values Education

Maye 1985	Fien and Slater 1981	Huckle 1981
a) Values Clarification b) Values Analysis c) Moral Reasoning d) Action Learning e) Values Inculcation	a) Values Clarification b) Values Analysis c) Moral Reasoning d) Values Probing	a) Values Clarification b) Values Analysis c) Moral Development d) Action Learning

An overall observation of this table (Table 4.1) shows that there appears to be significant overlap between the different authors, regarding the choices of teaching strategies for values education. Despite the fact that all the authors use similar terminology this does not necessarily mean that they are in total agreement as to the definition of each of the terms. Thus it is important, for the purposes of this research, to gain a deeper understanding of each of the seven strategies identified. A closer examination is necessary in order to try and determine a strategy which is appropriate for EE.

Table 4.2 gives a detailed analysis of all seven teaching strategies as suggested for values education.

TABLE 4.2 : A Detailed Description of Teaching Approaches for Values Education

Approach	Purpose	Methods
Values Analysis	To help pupils use logical thinking and analysis to decide upon values issues.	Simulation games, case studies, debates and structured discussions where pupils are expected to substantiate their points of view with evidence and reasing.
Values Clarification	To enable pupils to become aware of their own values, and to try and let them arrive at their own values choices by themselves in a non-threatening situation.	Role-playing exercises, simulation games, group discussions, self-analysis exercises.
Values Inculcation	To get pupils to accept a predetermined set of values.	Laying down set rules for behaviour, negative and positive reinforcement, teachers modelling 'acceptable' behaviour, telling stories which might'inspire' pupils to model their behaviour.

Approach	Purpose	Methods
Values Probing	To allow pupils the opportunity to evaluate an issue, when trying to understand the values which underlie different view-points from their own set of values. To encourage pupils to re-examine their own values, and possibly change them.	Role-play exercises, simulation games, case studies, debates.
Moral Development	To help pupils develop confidence in discussing their own value positions in the hope that through hearing other view-points it will help foster change in the pupils' reasoning	Group discussion around a controversial or argumentative issue.
Moral Reasoning	To get pupils to make moral choices on their powers of reasoning.	Pupils are presented with a moral dilemma story in which a principal character reaches a point in the story where he/she has to make a decision on a values issues. The story stops

TABLE 4.2: (continued)

Approach	Purpose	Methods
		at this point, and the pupils are required to think through and decide upon the values issue themselves.
Action Learning	To give pupils the opportunity for social action based upon their own values.	Simulation games, collecting data in the field, e.g. surveys, questionnaires. Becoming more involved e.g. writing letters of protest, petitions, demonstrations, publicity campaigns, physical involvement, e.g. taking part in an alien vegetation hack.

(after Maye, 1985, pp.34-40; Fien and Slater, 1981, pp. 43-49; and Huckle, 1981 pp. 154-55).

The differences between the strategies are that they have each been developed with a particular purpose in mind. No one approach is better than the other, because they all have their own particular strengths and weakness. For example, the values inculcation approach might be deemed to be nothing less than indoctrination, while on the other hand, people should be told that polluting a river is unacceptable. These points must be taken into account when planning any learning experience involving values, otherwise it could lead to the reduced effectiveness of values education. Fien and Slater (1981, p. 50) provide the following reminder that

> "early environmental educators believed that teaching the right facts about the environment would lead to appropriate environmental ethics. However, they failed, despite their good intentions. We could also, in our use of the recently developed strategies for values education".

To avoid pitfalls, educators need to choose a teaching approach most suited to their particular educational objectives and situation.

One specific teaching technique has been singled out for this particular study, namely the simulation method. The reason for this is based on the researcher's view that this method incorporates a number of approaches within values education, it is compatible with the aims and objectives of EE, and it can be identified with Reconstructionist philosophy.

4.2 THE SIMULATION TEACHING METHOD

4.2.1 Definition of Simulations and Simulation Activity

In order to understand the difficulties inherent in defining simulations in education, one needs to examine its origin. Before doing this one needs to appreciate that any mention of gaming or games within the classroom is normally regarded by many educators and parents, as merely fun and entertainment, and not learning.

Secondly, simulations are often regarded as being synonymous with games, thereby reducing simulations to non-academic fun exercises. Jones (1985, p. 3) points out that this is indeed "confusing in an educational context, where 'game' has its own distinctive connotation". The near-synonymous nature of many of the other terms associated with simulations (e.g. simulation, role-play, game, educational game and simulation game) only exacerbates this problem further.

Walford (1973) regards role-playing exercises and games as being different types of simulations. Fien, Hodgkinson and Herschell (1985) would agree with Walford that role-play is a form of simulation. However, they make clear distinctions between simulations, educational games and simulation games. They define the three techniques as follows :

(a) a simulation is an activity based on reality, whereby pupils use a model or role-playing to try and understand that reality;

(b) an educational game is a competitive activity based on chance, in which pupils using skills and data compete against each other for an objective (e.g. winning); and

(c) a simulation game is the combination of the elements of simulations, role-play and educational gaming.

These definitions correspond with those drawn up by the Society For Advancement of Games and Simulations in Education and Training (SAGSET) (SAGSET publication, 1986). The above techniques owe their existence to the age old concept of gaming.

The concept of gaming has a long history and association with war and military strategies. The earliest recorded use of war-games is attributed to the Chinese in c.3000 B.C. (Taylor and Walford, 1978). War-games then seemed to have lost their popularity until they emerged again during the 18th century. However, they really came into prolific use during the First and Second World Wars.

The technique of 'acting-out' reality, and its apparent success, undoubtedly led to its use in other formats. For example, flight simulators (i.e. real-life replicas of aeroplane cockpits, and the simulated conditions associated with flying), were used to train pilots and cabin crew. Business games emerged during the 1950's.

The simulation methodology was first recognized by educators as being of educational importance during the 1960's (Boocock and Schild, 1968). However, this was not immediately accepted or used by educators because of the problem of definition mentioned above.

Due to this same problem, the researcher has been prompted to use the collective term simulation when referring to this particular teaching method. The reasons for this are that, in trying to develop a teaching method for EE, it is obvious that one needs to incorporate various aspects of gaming, role-play and simulations, therefore the outcome may not necessarily correspond with those put forward by Fien et al and SAGSET (SAGSET publication, 1986). This has also led to the use of the term, simulation activity which represents the researcher's interpretation of what constitutes or should constitute the actual activity. This was deemed necessary because of the negative connotations associated with the term game. Therefore, according to this reseacher a simulation activity can be described as follows:

(a) a simplified form of reality;

(b) it has rules, but it is not a contest involving competitiveness and winning;

(c) it involves role-play;

(d) it has an objective viz. solving a problem;

(e) it has a time limit; and

(f) it is an academic exercise, but it does have an enjoyment aspect.

4.2.2 **Advantages and Disadvantages of the Simulation Technique for Enviromental Education.**

The following table (Table 4.3) illustrates the advantages and disadvantages of simulation activities.

TABLE 4.3 : Advantages and Disadvantages of Simulation Activities

ADVANTAGES	AUTHORS
They generate interest and involvement. Players learn from participation.	Boocock & Schild, 1968, p. 19.
They establish a setting wherein theory and practice can be joined. They make students take personal decisions based on their informal stand and bear the consequences.	Cruikshank, 1971, pp. 180-190.
They are psychologically engaging (i.e. once the student has made a decision based on personal experience, knowledge and values he can enter into dialogue with one or more problem solvers). They create models of reality. They enable the student to be himself/ herself.	Cruikshank, 1971, pp. 188-190.

Table 4.3 : (continued)

ADVANTAGES	AUTHORS
Device for motivating students. Means of altering attitudes. Means of acquiring factual and conceptual knowledge. Means of acquiring and improving social skills and to gain confidence in using these skills.	Garvey, 1971, p. 209.
Used as a "social laboratory" (i.e. opportunity to utilize in artificial environment, knowledge previously acquired, and to gain some comprehension of complexities of selected social processes. Means of creating better teaching atmosphere. Help encourage more effective learning of subject-matter. Will enhance problem-solving. Improves student motivation.	Walford, 1981, p. 118

TABLE 4.3: (continued)

ADVANTAGES	AUTHORS
Simplification of a situation (i.e. reduce it to its essentials). Compression of time (i.e. to bring situations within classroom study). Localisation of context (i.e. to focus attention on a particular theme).	Walford, 1973, p. 1
Form of experiential learning.	Thatcher,1986, p.14
Means of understanding and evaluating the operation of theory in practice.	Taylor & Wynn, 1984 p. 241
Students able to explore controversial issues and clarify their own values. They generate enthusiasm for and/or a commitment to learning in general. They can be incorporated with other teaching strategies. They create a flexible, responsive learning environment.	Fien, Herschell and Hodgkinson, 1985, pp. 115-116.

TABLE 4.3: (continued)

ADVANTAGES	AUTHORS
Bridges the gap to reality. Demands that students be flexible in their thinking. Dynamic teaching technique. Removes student-teaching polarization. Learning takes place at diverse levels. They present an inter-disciplinary view. Seen as a universal behaviour mode (i.e. children learn to play games from earliest years). Break-away from 'conventional wisdom' (i.e. few participants will have 'cookbook' solutions or even body of theory - thus a level of freshness and novelty is maintained).	Taylor and Walford, 1978, pp. 27-36.
Form of experiential learning.	King, 1981, p. 111

TABLE 4.3: (Continued)

DISADVANTAGES	AUTHORS
Do simulations really teach? They have undesirable elements (e.g. they equate success with profitability, they are competitive, etc). They are dangerous (i.e. they may affect the child emotionally or they may present/promote wrong ideas). Time factor (too long, difficult to programme).	Walford, 1975, pp. 161-175.
Difficulties of availability and cost. Operational problems (too many rules, sub-sections, annexes, etc).	Taylor and Walford, 1978, pp. 37-38.
Possibility of inappropriate use (e.g. used as an end-of-term 'lollipop').	Walford, 1981, p. 118
Different users tend to have different interpretations of 'success'. Illusion of open-endedness created (i.e. simulation may appear democratic way of learning but it is important to scrutinize the model itself).	Walford, 1986, p. 83.

TABLE 4.3: (Continued)

DISADVANTAGES	AUTHORS
Problem of trying to replicate reality.	Walford, 1986, p.83
They do not produce more student motivation and interest compared to other teaching methods.	Cherryholmes, 1966 p. 6
Limited, in that they may be able to induce inactive and iconic learning only (i.e. they teach psychosociological dimension only rather than cognitive and factual dimension. Problem of validity and reliability of original data.	Inbar and Stoll, 1970, p. 53
Little evidence to support argument that they train people in decision-making skills or influence their ability to resist propaganda.	Scarfe, 1971, pp. 201-203
Not an end in itself.	Taylor & Wynn, 1984 p. 241
Operation/design problems.	Fien et al, 1985, p. 115

It is important that in studying Table 4.3, one does not lose sight of the following :

(a) that these advantages and disadvantages are based on definitions and experiences of particular authors, and

(b) the simulation technique must not be regarded as an end in itself, but must rather be seen to form part of the pedagogical process.

It is the opinion of the researcher (based on the table) that because simulation activities:

(a) can promote critical thinking and problem-solving;

(b) are a means of creating an interesting (for the pupils and teachers) teaching atmosphere;

(c) can develop and improve social skills;

(d) are an effective teaching method (pupil-centred);

(e) can give pupils a closer understanding of the real world;

(f) present an interdisciplinary medium of instruction;

(g) can deal with the acquisition of knowledge, concepts and attitudes;

(h) can possibly help to motivate pupils;

(i) can promote decision-making skills;

(j) can be operated in conjunction with other teaching strategies and;

(k) enable pupils to deal with controversial issues and clarify their own attitudes and values.

This particular teaching method can be an effective way of teaching EE. This view is also supported by Molenda (1978) who gives five reasons why all environmental educators should give serious thought to using simulations when teaching EE. They are as follows:

(a) the simulation technique is a current and expanding educational innovation;

(b) the simulation technique seems to coincide with EE's aims and objectives;

(c) the simulation technique is seen as a way in which the principles of behavioural science can be introduced into the teaching-learning process;

(d) there is a vast quantity of simulation resource material available; and

(e) simulations are a technique which can be designed and produced by educators themselves.

The use of simulations as a method for teaching EE is also strongly supported by Taylor (1983) in his guide on the design of simulations for EE, which was commissioned by the UNESCO - UNEP 'International Environmental Education Programme' (IEEP). He contends that there is much common ground between simulations and EE's aims and objectives. These are shown to overlap in six particular areas as both emphasise

"(a) adventurous exploration and enjoyable involvement;

(b) extensive interdisciplinary participation;

(c) decision-making anchored to complex practical problems - and living with the consequences of decision-making;

(d) improving performance, through applying knowledge, considering values, perceptions, decision options and responding to feed back; and

(e) setting verbalization and social skills alongside numeracy and literacy." (Taylor, 1983, pp. 7-8).

4.3 <u>CONCLUSION</u>

Although there is a real need for a revolutionary change in the educational philosophy and policy in South Africa, it does not necessarily mean that attempts cannot be made to teach EE in secondary schools in this country, before all these changes occur.

Values education offers many appropriate techniques for the teaching of EE. Simulations however, appear to be the technique most applicable, because they

(a) are compatible with Reconstructionist philosophy (which facilitates decision-making and encourages listening to other people's points of view);

(b) are compatible with the aims and objectives of EE;

(c) are recognised as a teaching technique for EE by UNESCO-UNEP International Environmental Education Programme; and

(d) are able to affect participants' knowledge, concepts, attitudes and behavioural intentions.

The following chapter deals with the design, implementation and assessment of the 'Coal or Nuclear' Simulation activity.

CHAPTER FIVE

THE DESIGN, IMPLEMENTATION AND ASSESSMENT OF THE 'COAL OR NUCLEAR' SIMULATION ACTIVITY

5.1 INTRODUCTION

Having decided to use the simulation method as a means of teaching EE, what remained was to demonstrate this in practice.

It was thus necessary to acquire a simulation activity. The next step was to establish whether any simulations were in existence or use in South Africa. The researcher found a simulation activity called 'The Environment Game'. After close examination it was found to be inadequate and outdated in parts. However, despite this setback, the simulation activity was still useful, because it could serve as a basis from which to design a more appropriate one.

Therefore the 'reusable' simulation design approach was opted for rather than the theoretical model approach, which required designing a model before designing the simulation activity, or the 'cooking-pot' approach which was largely a trial and error method.

The design of the simulation activity was also based on the overall aims and objectives of the research project, as perceived by the researcher.

The overall aims and objectives were as follows:

(a) to design a simulation activity as one means of teaching EE in South African secondary schools;

(b) to test the effectiveness of this simulation activity.

The more specific goals of the simulation activity were:

(a) to create a holistic and interdisciplinary understanding of the implications of the human-environmental crisis;

(b) to give pupils the opportunity to examine their own and others' attitudes and values with regard to the total environment and environmental issues (in particular the Coal/Nuclear issue);

(c) to convey the complexity and seriousness of environmental issues;

(d) to show pupils how environmental issues involve them personally;

(e) to provide pupils with a relevant, interesting "hands-on" experience of a real-life South African environmental issue;

(f) to allow pupils to practise decision-making and problem-solving skills; and

(g) to persuade pupils to understand that local and national environmental problems can have international consequences.

(h) to give pupils the opportunity to acquire environmental knowledge and concepts.

In terms of assessing the successfulness of the simulation technique a questionnaire approach was chosen for the following reasons :

(a) it is relatively quick and easy to administer;

(b) it is "a favourite research technique among pioneers of simulations" (Jones, 1985, p. 80);

(c) the questionnaire technique is effective in gathering not only factual information but also in acting as a means of assessing attitudinal changes in respondents (Ballantyne, 1987); and

(d) the results of a questionnaire can be used to provide statistical evidence to support the aims of this study.

The choice of this particular technique meant that the researcher had to be aware of the following:

> "questions may be left blank, misunderstood or incorrectly filled in. Where unsatisfactory returns are widespread, it suggests that the question(s) or technique were wrong for either the topic or the respondents; pilot testing should discover this" (Dixon and Leach, 1977, p.7).

5.2 THREE APPROACHES IN THE DESIGN OF SIMULATION ACTIVITIES

5.2.1 The Theoretical Model Approach

In this approach it is necessary to design a theoretical model or framework before producing a simulation activity.

Gibbs (1974) has designed such a model (Figure 5.1), based on the work and ideals of numerous authors (Clayton and Rosenbloom, 1968; Glazier,1969; Loveluck, 1969; Walford, 1969; Tansey and Unwin, 1969; Abt, 1970; McLeish, 1970); (Gibbs, 1974, p.35).

Gibbs' model, with its 14 different yet related stages, might at first appear rather daunting to the novice simulation designer. On the other hand, it is very clear, logical and well-structured in its lay-out.

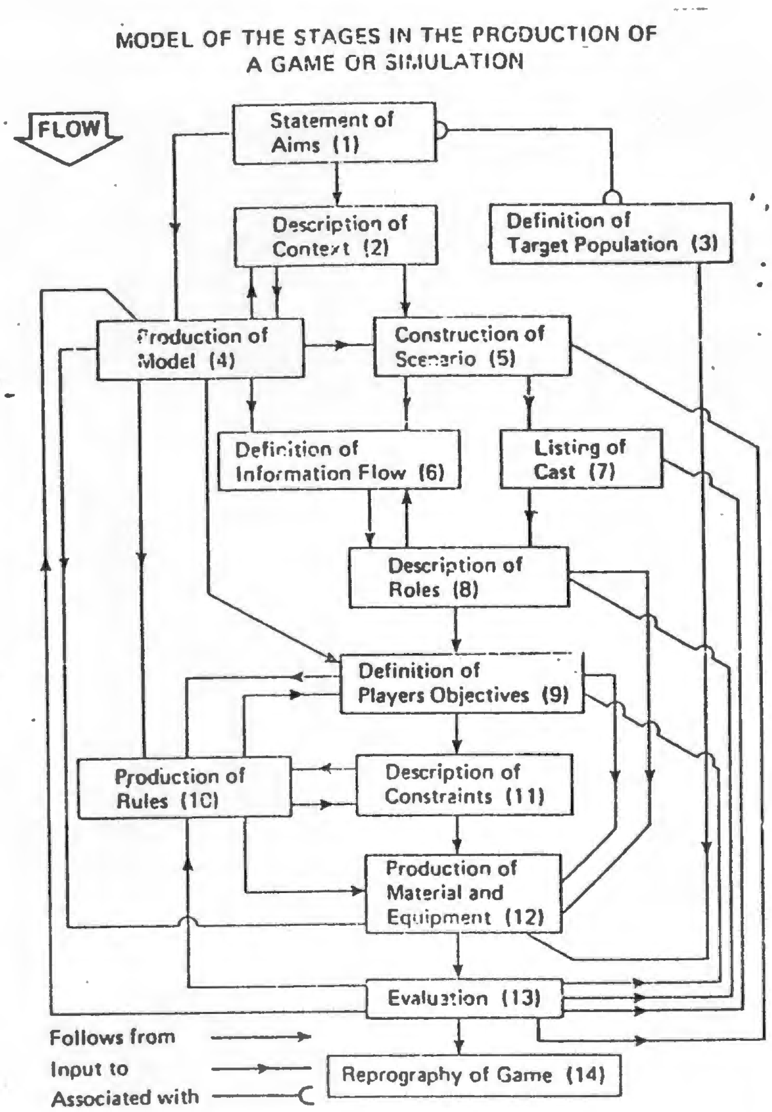

FIGURE 5.1: <u>**Gibbs' Model of Simulation/Gaming Design**</u>
(Gibbs, 1974, p.35).

Despite the apparent wide support for and the practicality of this approach, it does have its critics, one of whom is Jones (1985). He refers to this approach as the "assembly-line" method, and makes three main objections

> "that it is sequential, that it inhibits effective authorship, and that it lends support to the damaging belief that a simulation should be a model of reality" (Jones, 1985, p. 13).

5.2.2 The 'Cooking-pot' Approach

This approach resembles a chef gathering a number of ingredients and placing them in a pot. Then by a process of trial and error, influenced by the chef's imagination, a dish will be produced.

The 'cooking-pot' approach could thus be seen as the exact opposite of the first approach mentioned. The problem with the 'cooking-pot' approach is that first-time designers who are unfamiliar with simulations, may struggle to design a simulation activity. One might also want the simulation activity to grow out of experience.

Although this open-ended, unstructured approach might suit those educators who are familiar with simulations, a well structured set of guidelines, such as those suggested by Gibbs (1974) might be more appropriate for novices.

Jones (1985, p. 15), however, while encouraging people to design their own simulations activities, does warn that "a difficult starting place for writing your first simulation is a blank sheet of paper. It is easier to start with someone else's event. If you are feeling nervous or apprehensive, then don't try to design a simulation from scratch, but start where another simulation ends".

This last comment leads one to the 'reusable approach'.

5.2.3 **The 'Reusable Approach'**

Miller (1982) and Walford (1986) also agree that if there is any doubt about being able to design a new simulation activity, then it is preferable to adapt or modify an existing one. This third approach may be referred to as the 'reusable approach'. This approach entails either the stripping down of an existing simulation activity to its barest frame, and then rebuilding it to the specific requirements of the new designer or alternatively, retaining, modifying and changing various parts as deemed necessary by the new designer. The reusable approach will, therefore, probably be the easiest method for the first time simulation designer to use.

Whatever approach is selected, is obviously a personal decision, based on the individual's confidence and overall simulation experience. However, Walford (1986), who is regarded by King (1981, p. 111) as being "the guru of geographical games" gives four important guidelines necessary when designing a simulation. They are as follows:

(a) the content materials of the simulation activity should be adaptable, so that subsequent educators/designers can adjust the activity to suit their particular objectives;

(b) simulation activities should be kept as simple as possible but one must also remember that the real-world situation is a complex one;

(c) the educator or designer should act with sensitivity when 'managing' the activity, because he/she must allow pupils the opportunity to explore the situation, and to examine the results of their actions, without intervening too often; and

(d) the simulation activity should be designed in such a way that it can be incorporated into any syllabi, and so that it can possibly act as a catalyst for further interest and learning.

Once a particular approach or combination has been decided upon, it is then necessary to follow a specific operational format, before the activity can be set up.

5.3 THE OPERATIONAL FORMAT FOR SIMULATION DESIGN

The sequence of events for the operational format of the simulation design should be based on the following steps:

(a) the briefing (the introduction or background to the simulation activity);

(b) the action (the actual "playing" of the activity);

(c) the debriefing (the follow-up after the activity has been "played").

It is evident that all three of these steps are going to be important in the design of a simulation activity. However, designers may pay less attention to the debriefing because, when the action component has ended, the entire activity may now appear to have ended. This is not so, and it is essential that a follow-up session takes place directly after the action component.

Jones (1985, p. 77) actually feels that the debriefing should be "a continuation of the simulation". There are numerous reasons for this:

(a) the debriefing creates an extension of the activity;

(b) it is an opportunity for the pupils (in maintaining their roles) to evaluate the activity from 'the inside' without inhibiting the pupil-teacher situation;

(c) it provides an extended period for organisational, communication and language skills to be developed;

(d) it is also an opportunity to keep the participants informed as to how their counterparts from other groups viewed the activity;

(e) it also creates the opportunity for pupils to apply their simulated experience to a real-life situation thereby validating the theoretical experience; and

(f) it is also an invaluable opportunity for the designer to gain insight into how the activity functioned, in terms of the participants and the activity.

5.4 THE DESIGN OF A SIMULATION ACTIVITY AND A METHOD OF ASSESSMENT/EVALUATION FOR ENVIRONMENT EDUCATION IN SOUTH AFRICAN SECONDARY SCHOOLS

5.4.1 Choice of Simulation Design Approach

After establishing that no research had previously been carried out using simulations in South African secondary schools, or any such activities had been designed for EE, and the limited experience with simulations of the researcher, it was decided to use the 'reusable' approach to design such an exercise for South African secondary schools. This particular approach proved to be the most suitable because the researcher found a simulation activity called 'The Environmental Game', which was apparently based on a game called 'Man and his Environment' published by the Coca-Cola Export Corporation. The adaptation and distribution of 'The Environment Game' was carried out by the now defunct National Resources Board of Rhodesia (Zimbabwe).

At first it appeared as if this particular simulation activity could be used as it was for the teaching of EE in South Africa. This opinion was formulated after studying the aims of the activity which were

> "to awaken in students an interest in and understanding of some of the principles of ecology and how man affects his environment; to show that all elements of the environment are inter-related and inter-dependent; to show that when man changes the environment, it has consequences not only for himself but for other forms of plant and animal life and for the soil and water; to show that all individuals contribute their portion to the problem, or cause others to do so in the process

of meeting his needs and demands" ('The Environment Game' p.1).

5.4.1.1 Problems Associated with 'The Environment Game'

However, on closer scrutiny a number of problems emerged. The most important of these was the fact that a simulation activity's effectiveness cannot be judged merely by its aims and objectives, but rather on how these are attained through practical application in the field. There was, however, no evidence available (other than verbal assurances) as to the success of 'The Environment Game'.

Added to this initial stumbling block there were a number of other problems associated with 'The Environment Game', namely

(a) it was outdated (in terms of being drawn up in a pre-independent Zimbabwe (i.e. before 18 April 1980) and thus reflected in its design and content the former White-dominated Rhodesian way of life);

(b) it appeared to be too cumbersome and complex (in terms of having a plethora of operational rules, instructions and pieces of equipment (59 pieces in all - which also included a base map measuring 90.5 cm x 71.5 cm in size); and

(c) it lacked a clear, concise operational format. No provision was made for a debriefing component and more importantly, it did not provide for any means of assessment or evaluation.

'The Environment Game', could thus not be used in its entirety by the researcher. Therefore, of the three approaches to simulation design, the 'reusable' approach appeared to be the most appropriate in this case, because it would allow for the incorporation of some of the features and ideas of 'The Environment Game' while devising an EE simulation activity particularly relevant to the South African situation.

5.4.1.2 The Overall Planning of the 'Coal or Nuclear' Simulation Activity

Having decided upon the use of the 'reusable' approach it was now possible to plan and design a South African EE simulation activity. The initial phase of the activity's design was based on the following five steps put forward by Cryer (1987) :

(a) aims and objectives;
(b) content;
(c) teaching/learning methods;
(d) constraints; and
(e) assessment/evaluation.

5.4.1.3 Aims and Objectives

A distinction was made between the overall aims and objectives of the research and the more specific ones of the simulation activity itself (as mentioned earlier).

5.4.1.4 The Content of the Simulation Activity

Keeping in line with the above aims, and from the point of view of observing EE as education for the environment, the content of the simulation was based on an environmental issue which could not be misconstrued to be non-political or neutral. Therefore it was decided to use an aspect of the Nuclear Power Debate, namely to consider the possible advantages and disadvantages of coal- fired power stations over those of nuclear power stations, as the central issue.

This issue was deemed to be of particular relevance for EE in South Africa for the following reasons:

(a) this country possesses large coal and uranium reserves;

(b) there are approximately 20 coal-fired power stations in this country;

(c) the Electricity Supply Commission (ESCOM) has embarked on a nuclear programme, with one nuclear power station already in operation at Koeberg near Cape Town, while more are planned for the future;

(d) acid rain and air pollution are some of the problems particularly associated with coal-fired power stations;

(e) possible nuclear melt-downs, radiation leaks, air and water pollution, problems of disposal of nuclear wastes and the threat of plutonium thefts are problems particularly associated with nuclear power stations;

(f) it is a national as well as an international environmental issue.

Based on the choice of this particular issue, the simulation activity in question was named the <u>Coal or Nuclear</u> simulation.

5.4.1.5 The Teaching/Learning Methods

It was decided to use a simulation activity (as explained in Chapter 4) as the teaching technique because of its compatibility with the principles of EE. A supplementary technique used was group work carried out during the simulation.

5.4.1.6 Constraints on the Research Project

There were many constraints, identified as follows:

(a) the limited time available to arrange school visits during term time;

(b) The time limit in respect of available time in the schools: simulation activities require a long time (1-2 hours) for the activity to be carried out, but to make it acceptable for use in schools it had to be restricted to approximately an hour. However, it can be ongoing if its application is relevant and the headmaster is flexible;

(c) the subject-orientated curriculum which does not lend itself for such a cross-curricular activity;

(d) the financial problems experienced in constructing the simulation activity (i.e. producing the various parts);

(e) the apparent apathy and lack of interest in EE and environmental issues in South African schools;

(f) the lack of teacher and pupil experience in the use of simulations activities; and

(g) the inhibiting effects of living in a relatively closed society with the inability to express ideas and carry out actions freely.

5.4.1.7 Assessment of the Effectiveness of the Simulation Activity.

It was difficult to decide which means of assessment to use for the simulation. The difficulties became evident at the outset when determining whether evaluation and assessment were one and the same or whether a distinction should be made between the two. Cryer (1987) believes that there is a difference, as she explains

> "evaluation tends to mean identifying the effects and judging the effectiveness of some learning experience, [while] ... Assessment (related to) student attainment before and after the learning experience might be an important part of evaluation." (Cryer, 1987, p. 55).

It was decided to use the term assessment, because in terms of the research, pupil attainment before and after the simulation activity (learning experience) was the important criterion.

Both Jones (1985) and Taylor (1987) identify various techniques for assessing simulation activities. They are observation by teachers, written reports, video recordings, attitudinal/behavioural tests, interviews and questionnaires. The optimum situation would be for all of these techniques to be incorporated in the assessment of a simulation activity. However, this was impossible and impractical due to the limited time and finances available to the researcher.

The questionnaire method thus appeared to be the most appropriate form of assessment for this research project. The following methods were not used because of their limitation for this research project:

(a) Observation by teachers and video recordings would only reveal visual impressions of the actual simulation activity. These methods, however, would not be able to assess whether pupils' knowledge, concepts, attitudes or behavioural intentions had changed or not.

(b) Attitudinal and behavioural tests would also be limited in scope as they would fail to ascertain whether pupils gained environmental knowledge and concepts when exposed to the simulation activity.

(c) Interviews are a useful method, in that it is possible to question any aspect of the simulation activity. It is also a very personalised account of how each individual reacts to the activity. However, the main drawback with this technique is time. Each participant in the simulation activity would have to be interviewed, and, if this is done immediately after the activity, it would take up a large part of the school day, which would not be acceptable to headmasters. Interviewing after school would probably result in resistance and apathy from school pupils. Each pupil would also have to be interviewed on three separate occasions (i.e. before and immediately after the simulation activity and after a prolonged period of time after the simulation activity had taken place), which would require many hours. Thus this method was not suitable for this particular study.

The design of the simulation activity and the questionnaire could now proceed.

5.5 DESIGNING THE OPERATIONAL FORMAT AND PROCEDURES OF THE 'COAL OR NUCLEAR' SIMULATION ACTIVITY

5.5.1 Introduction

Having completed the overall planning, it remained to design the operational format for conducting the simulation activity.

In keeping with the operational format of simulation activity design (mentioned earlier), the "Coal or Nuclear" simulation activity was divided up into three components:

(a) briefing,

(b) action, and

(c) debriefing

5.5.2 The Briefing Component

This introduces the "Coal or Nuclear" simulation activity, and as such is kept short (approximately 15 minutes). However, it is an important part of the simulation activity in that it is here that the operating rules and requirements are made known to the participants (Appendix 1). After selecting individual roles for themselves, the participants are divided up into six randomly-selected groups. Each group then elects one of its members to represent it in a newly created seventh group, i.e. the Management Committee.Each group represents an electoral ward (i.e. 1 - 5) except group six which represents the nature conservationists at the Simonsville Nature Reserve. It must also be noted that the sixth group from the Simonsville Nature Reserve, although represented at the meeting, and on the Management Committee, have no vote (because they are not ratepayers). Despite this draw-back they do have the opportunity to voice their views and opinions. All the groups then elected a chairperson. The Management Committee's elected spokesperson then takes on the role of mayor/mayoress. He/She is then separately informed about the leadership role which he/she is to play during the action component (Appendix 6). The six groups (1 - 6) are then arranged in a half- moon formation, all facing the Management group. At this point the action component is ready to commence.

5.5.3 The Action Component

In designing the action component Jones' (1985) key questions were used as a framework for the particular structure and content of this section.

These questions are:

(1) What is the problem?

(2) Who are the participants?

(3) What do they have to do?

(4) What do they have to do it with?"
(Jones, 1985, p. 17)

The first question covers the central problem or issue around which the simulation activity will revolve. The particular problem chosen for the "Coal or Nuclear" simulation activity is the choice facing a fictitious town, Simonsville, as to whether they should build another coal-fired power station or opt for a nuclear-powered one.

The second question refers to the actual participants of the simulation activity. In this case, the participants for the "Coal or Nuclear" simulation activity are to be secondary school pupils who role play 'actual' residents living in Simonsville.

The third question covers the task which the participants in the simulation activity will tackle. This task is to discuss and debate the coal/nuclear issue illustrated above using the information supplied. After reaching consensus, each group registers one vote, supporting either a coal-fired or nuclear-fired power station, while the mayor/mayoress has the casting vote in the case of a tie.

The fourth question deals with the materials supplied with which participants are to use in order to help them complete the given task. All seven groups in the "Coal or Nuclear" simulation were given a file containing the following:

(a) Setting the Scene - Notes for participants (Appendix 2);

(b) information sheets dealing with the pros and cons of nuclear power and coal-related issues (Appendix 3).

(c) a reduced map of Simonsville (21 cm x 31 cm) (Appendix 4).

A large base map of Simonsville (90 cm x 64 cm) is placed in front of the participants, so that they can identify their particular group with their electoral ward in

Simonsville, as well as noting where key points are, e.g. proposed site for nuclear power station, nature reserve etc. The participants are now informed as to what is to happen in the action component (Appendix 5). The pupil playing the part of the "mayor/mayoress" then starts the activity based on the set of instructions in Appendix 6 so designed that he/she can lead and control the action component from beginning to end without undue help or interference from the researcher.

The action component of the simulation activity is concluded by the groups taking a collective vote on the issue. The time allocation for the action component is approximately one hour.

5.5.4 The Debriefing Component

Immediately after the voting has ended and the result announced, the researcher, assuming the role of a central government official addresses the representatives of Simonsville. He asks if there were any problems or difficulties experienced during the meeting and subsequent voting. After this discussion (approximately 5 minutes) the participants revert back to pupil - teacher status for a final discussion where pupils give their views, opinions and criticisms of the simulation (approximately 10 minutes).

5.6 DESIGNING A QUESTIONNAIRE AS A MEANS OF ASSESSING PUPIL'S RESPONSES TO THE 'COAL OR NUCLEAR' SIMULATION ACTIVITY

5.6.1 Introduction

The results of the simulation activity need to be assessed in terms of the degree of success they have had in relation to the aims of this study. As discussed earlier the method of assessment decided upon was the questionnaire technique.

A number of guidelines and criteria set out by Dixon and Leach (1978) for the design of a questionnaire were adhered to. Academics in the field of educational psychology and testing were also consulted in the design process.

5.6.2 Questionnaire Design

In order to evaluate the results of the simulation activity the questionnaire had to be able to test the individual's environmental perceptions on three levels (i.e. cognitive, affective and conative).

This meant that the questionnaire had to be able to:

(a) assess whether pupils acquired environmental knowledge and concepts as a result of exposure to the simulation activity;

(b) assess whether pupils' environmental attitudes changed after the learning experience; and

(c) to assess whether the simulation activity acted as a catalyst for changing pupils' behaviour with regard to environmental issues.

In order to be able to do all of the above effectively it was decided that three questionnaires would be necessary. One was needed before the simulation activity in order to test environmental knowledge, concepts, attitudes and behavioural intentions of the pupils' prior to exposure to the activity. A second questionnaire was needed directly after exposure to the simulation activity to ascertain whether any changes took place during the simulation activity, while a third questionnaire was necessary long after the simulation activity had happened in order to indicate whether there was a drop-off effect or not.

The initial questionnaire (Appendix 7) comprised six sections, under the following headings:

(a) personal data

(b) environmental concepts

(c) environmental knowledge

(d) environmental attitudes

(e) behavioural intentions

(f) experience of simulations as a teaching method.

The first page briefly explained the purpose of the questionnaire. It also stated that the information given would be held in the strictest confidence.

It was found to be more convenient(by the researcher) to have the personal data on the first page of the questionnaire, as it was felt that these questions would relax the pupils and give them confidence right at the start.

The personal data asked for was the respondent's name, date of birth, sex, possible membership of an environmental/conservation group and school subjects. This particular collection of information was required for later comparisons in the analysis of the data.

The remainder of the questionnaire consisted of four sections as follows :-

(a) environmental concepts (made up of nine multiple-choice questions);

(b) environmental knowledge (made up of nine multiple-choice questions);

(c) environmental attitudes (made up of 23 Likert-type attitude statements); and

(d) behavioural intentions (made up of ten Likert-type attitude statements in the first questionnaire, and eight in the two subsequent questionnaires).

The decision for the separation of the questionnaire into four distinct sections was based on advice given to the researcher by the Psychology Department of the University of Cape Town.

The concepts section included a number of questions relating to the basic principles of ecology. The remaining questions covered other environmentally important concepts. These particular questions were chosen in the belief that pupils should grasp basic ecological principles in order to be able to understand broader environmental issues, such as the coal vs. nuclear debate.

The knowledge section, on the other hand, contained only nuclear or coal-related questions. The simulation activity centred around these particular environmental issues. It was therefore deemed appropriate to relate all the questions in this section to the topic of the simulation activity. It should be noted that, unlike the questions in the concepts section, some of the knowledge questions (No's 21 - 25) were chosen in the hope that they would probably not have been covered by the respondents' Biology, Geography or Physical Science syllabi. The reason for their inclusion was based on the supposition that, if the respondents had no prior knowledge of them and were then exposed to the answers during the simulation activity, the results for interval 1 (between the first and second questionnaires) should show an improvement in this section.

In the attitudes section only nine out of the 23 Likert-type attitude statements were connected with nuclear or coal-related issues. The other 14 statements were an assortment covering various aspects of the human-environmental crisis. Again the questions were specifically designed to make the attitude statements reflect the interrelated and holistic nature of environmental education.

The last section contained eight Likert-type attitude statements (ten in the first questionnaire) which were concerned with the degree of action pupils were prepared to take in response to environmental issues. The level of involvement varied from deciding whether to read more about environmental or conservation issues to deciding whether one should actually take part in a demonstration.

Overall, the four sections of the questionnaire, were drawn up so that they would reflect the aims and objectives of environmental education.

These include : the acquisition of environmental concepts and knowledge; the development of positive attitudes towards the environment, and the need for action in solving environmental problems.

The last section contained two questions which asked the respondents to state whether they had had previous experience in the simulation technique and, if so, to state in which subjects (these questions were only asked in the first questionnaire). This information was to be used later, during the analysis of the data. Attention now had to be given to choosing the research group.

5.6.3 <u>Choice of Research Group</u>

Before embarking upon this task, a number of educational realities had to be taken into account. These were as follows :

(a) South African government schools are racially segregated, and administered by separate provincial education departments and an Own Affairs parliamentary ministry;

(b) different languages are used as mediums of instruction in the various secondary schools (e.g. English and/or Afrikaans);

(c) the Government's policy of Christian National Education does not support the concept of cross-cultural, sporting and social interaction of school pupils from different racial groups;

(d) disruptions (class boycotts, police intervention and various instances of violence) within Black, Coloured and Asian schools (1976, 1980, 1985, 1989 and 1990) against segregated and inferior education, are continuing; and

(e) under the present state of emergency, numerous pupils, teachers and administrators have been imprisoned or detained, while certain schools have been temporarily or permanently closed.

Taking the above realities into consideration, and because of:

(a) the fact that all the researcher's teaching experience has been in White, English-speaking (Cape Education Department) secondary education in the Cape,

(b) the difficulties envisaged in trying to gain permission from the Cape Education Department (C.E.D.) to carry out research in non-C.E.D. schools, and

(c) the limited scope of this study

it was decided that the simulation activity would be tested only in White, English-speaking secondary schools in the Cape Peninsula.

Based on the above, the choice of determining who the study group would be thus hinged on two criteria: firstly, if the study was to deal with EE, then it had to be interdisciplinary in nature (i.e. all subjects would have to be represented), and secondly, if the pupils involved were required to deal with complex mental processes (such as attitudes and values) then Piaget's formal operations stage of mental development would have to have been reached.

Pupils having reached Piaget's stage of formal operations are reputed according to Naish (1982) to be able to:

(a) deal with the concept of assumptions;
(b) understand and use hypotheses;
(c) define general laws;
(d) understand proverbs;
(e) think in abstract terms; and
(f) become aware of their own attitudes and beliefs.

This stage of mental development is apparently reached at the age of eleven and a half years (ibid, 1982). However, it must be remembered that a child's chronological age does not necessarily correspond directly with their mental development (Stones, 1978, p.46).

In view of this, it was decided to use a standard nine English-subject registration class as the study group. The particular reason for this choice was twofold: as an English-subject class English would be a common subject to all of the pupils, (thus being testable at the same time) and all would be on average 16 years old and therefore capable of handling complex mental processes.

In consultation with a lecturer in the Department of Mathematical Statistics at the University of Cape Town it was decided to use a group of at least 200 pupils or more in the study. In order to achieve this number, it was planned to use eight classes of approximately 30 pupils drawn from eight different secondary schools. This would adequately cover the required 200 because the original figure would fluctuate due to factors such as unequal numbers of pupils per class and pupils' being absent from school.

5.7 PILOT TESTING THE "COAL OR NUCLEAR" SIMULATION ACTIVITY AND QUESTIONNAIRE.

It was essential to conduct a pilot study before carrying out the actual simultation activity and questionnaires in order to give the researcher the opportunity to refine and adjust the instruments after exposure under actual operational conditions.

A group of standard nine pupils (71 in total) from a Cape Education Department (C.E.D.) co-educational English-medium school was used in the pilot study.

The researcher was fortunate to be able to use all the school's standard nine pupils for four consecutive teaching periods (40 minutes each). It was therefore possible to obtain a cross- curricular effect i.e. all subjects would be represented, and also to cover the entire academic spread offered at this particular school.

The study was carried out in the school's gym hall as it was more conducive to group work with such a large number of pupils.

The pilot-study programme consisted of the following:

(a) a brief introduction, whereby the overall purpose of the research project was explained to the pupils (10 minutes);

(b) a questionnaire, before the simulation activity (Appendix 7) (25 minutes);

(c) a break for relaxation (15 minutes);

(d) a briefing session, where the purpose of the Coal vs Nuclear simulation activity was explained to the pupils, and what was required of them throughout the simulation activity (15 minutes);

(e) the action component, when the simulation activity actually took place (80 minutes); and

(f) a debriefing session, immediately after the simulation activity; (15 minutes).

(g) an identical repeat questionnaire, after the simulation activity (25 minutes) which formally ended the pilot-study.

A number of points emerged as a result of the pilot-study with regard to both the simulation activity and the questionnaires. Those relating to the questionnaires are presented first. They are as follows:

(a) the section headed Environmental Concepts should not have been where it was at the bottom of page one, on its own, but rather on page 2 where the first question dealing with environmental concepts began;

(b) some questions were found to be rather ambiguous, grammatically incorrect or poorly phrased. (e.g. Questions 9, 12, 17, 18 and 20) and these needed to be rectified;

(c) it was felt that more than four questions were needed to adequately test the pupils environmental knowledge before and after the simulation activity;

(d) some attitude statements were found to be inappropriate or in need of adjustment (e.g. Questions 23, 26, 27, 28, 30 and 38) because they were poorly worded, too simplistic or ambiguous;

(e) sixteen attitude statements in the environmental attitudes section were not sufficient because one of the main features of the research was to see whether pupils' environmental attitudes changed or not. This meant that a wider spread of environmental issues had to be covered, while making sure that the coal/nuclear issue was adequately represented;

(f) it was also felt that more attitude

statements were needed in the category dealing with behavioural intentions because four such statements were not considered to be enough from which to assess whether pupils' behavioural intentions had changed or not;

(g) it was decided to include more open-ended questions in the last section of the questionnaire, so that pupils could freely express their opinions in terms of evaluating the 'Coal or Nuclear' simulation activity as a teaching method. It was felt that "closed" questions, with merely right or wrong answers, could not adequately deal with this aspect of pupil response;

(h) it was felt that the Likert method of summated ratings, used to rank attitude and behavioural intention statements, should be reversed (i.e. strongly disagree, disagree, uncertain, agree, strongly agree). In mathematics and scientific deduction it is a matter of protocol to have negatives on the left and positives on the right;

(i) it was felt that the section on the evaluation of simulations as a teaching method should consist only of Questions 57 and 58 in the first questionnaire (before the simulation activity), while the second questionnaire (after the simulation activity) would contain an extra question, namely 59 referring specifically to the 'Coal or Nuclear' simulation activity. The final questionnaire would not contain this section at all, because it was deemed unnecessary, and the questions related specifically to events before and directly after the simulation activity;

(j) it was thus confirmed that this questionnaire with the suggested modifications and adjustments would be capable of evaluating the effectiveness of the simulation activity and assessing whether the pupils' environmental knowledge, concepts, attitudes and behaviour had changed.

After taking the above into consideration it was decided to use three questionnaires, one before the simulation activity, one directly after and a third and final one at least three months after.

The questionnaires would be identical, the reasons for this being that the first questionnaire would establish the pupils' initial environmental knowledge, concepts, attitudes and behavioural intentions before the simulation activity, while the second would establish whether any changes had occurred as a result of the activity, the final questionnaire would assess the drop-off and long-term effects.

The following points of interest relate to the simulation activity:

(a) the information files supplied to each group appeared to contain too much information and would have to be reduced as the groups were not reading through all the sheets before discussions took place;

(b) observations made led the researcher to believe that the majority of pupils had very preconceived ideas and views about nuclear issues. The pupils appeared strongly pro-nuclear at the outset, and did not appear to read the information files, but launched straight into discussions;

(c) the need was expressed to provide each group with a reduced version of the base map of Simonsville (the simulated area) instead of there being only one large copy in front of the groups; and

(d) pupils seemed to be self-conscious about 'playing' roles. This could possibly be attributed to the fact that very few of the pupils, when asked, had ever experienced a simulation activity before, and not many had experience of role-playing exercises either.

A general point of concern which emerged after conducting the pilot-study was the length of time taken for the entire programme to run. It would not be possible to acquire the same period of time (i.e. 160 minutes) in other schools. Firstly, headmasters would probably not be keen to give the researcher so much of the teaching day, and secondly, teaching periods tend to differ from school to school in terms of length of time (e.g. from 35 minutes to 60 minutes), and different schools run various set programmes (eg. weekly test series).

It was therefore decided to request the following time allocation for the research programme, firstly, from the Cape Education Department and secondly, from headmasters:

(a) one lesson for the pre-simulation activity questionnaire on Day 1;

(b) one lesson for the briefing on Day 1;

(c) two lessons for the simulation activity on Day 2;

(d) one lesson for the debriefing on Day 2;

(e) one lesson for the post-simulation activity questionnaire on Day 3.

5.8 IMPLEMENTATION OF THE 'COAL OR NUCLEAR' SIMULATION AND THE ACCOMPANYING QUESTIONNAIRES IN EIGHT CAPE EDUCATIONAL DEPARTMENT (C.E.D.) SECONDARY SCHOOLS

5.8.1 Introduction

After completing the necessary adjustments and improvements to the questionnaires and simulation activity, the necessary permission had first to be granted by the Cape Education Department before the research could go ahead in government schools.

Although this permission was granted, a number of conditions were attached (Appendix 9). There was only one real problem: no research was allowed to be conducted in schools during the last term (fourth term) and this was the term during which the final questionnaire was to have been administered. The reason for this was that a long period of time between the simulation activity and the final questionnaire was required, in order to measure the long-term effects of the simulation activity. Accordingly, it was decided to administer the third questionnaire, as late as possible during the third term.

Having obtained Departmental approval the researcher then approached the relevant headmasters to make arrangements for conducting the research at their schools.

5.8.2 Implementing the Research Programme in the Eight Cape Education Department Secondary Schools

Headmasters of eight C.E.D. high schools who agreed to take part in the research programme were telephoned and arrangements for the researcher's visits to their schools were confirmed.

However, the researcher's original plans were not entirely met. Firstly, it was not possible to obtain the use of a standard nine English-subject register class in all eight schools (this was possible in only three out of the eight - the other classes being made up of Geography and/or Science/Mathematics subject groups). Secondly, most headmasters found it impractical to give one class so much time off (i.e. six periods). This request was renegotiated and finally all eight schools agreed to allow the researcher access to the pre-arranged groupings on three separate occasions. The first and last visits were to be twenty-five minutes each, while the second visit was to be two hours and fifty-five minutes.

The first visit to the schools was for the completion of the pre-simulation activity questionnaire with a time allocation of 25 minutes.

The second visit was the longest (time allocated 175 minutes). The allocated time was further split up by the researcher and used as follows:

(a) fifteen minutes for the briefing session where the operating instructions of the simulation activity were given to the pupils, as well as arranging pupils into randomly pre-selected groups;

(b) sixty minutes for the individual groups to read and discuss the issues at hand, and to arrive at a group decision regarding the issue;

(c) ten minutes for a break;

(d) forty-five minutes for a report-back session in groups. Each group through an elected spokesperson presented its standpoint and choices to the rest of the pupils. At the end of this session a vote was taken to establish whether the groups (collectively) were for or against the building of a nuclear power station;

(e) fifteen minutes for a report-back immediately followed by the debriefing session during which time the pupils (still encouraged to retain their roles) were allowed to express their feelings, attitudes and general comments about the simulation activity);

(f) ten minute break; and

(g) twenty minutes for the pupils to complete the post-simulation activity questionnaire.

The third visit to the eight schools was scheduled to take place for the administration of the final questionnaire in the latter part of the third term.

The third questionnaire was thus carried out on the following days at the specific schools :-

School 1	16 October	10 weeks after the game
School 2	18 September	7 weeks after the game
School 3	22 September	7 weeks after the game
School 4	23 September	7 weeks after the game
School 5	17 September	6 weeks after the game
School 6	22 September	5 weeks after the game
School 7	23 September	5 weeks after the game
School 8	22 September	5 weeks after the game

The final questionnaire was thus unavoidably administered at different times after the second questionnaire at each school. The consequence of this action in terms of how the validity of the conclusions may be affected may emerge in the results.

5.9 CONCLUSION

Using 'The Environment Game' as a basis together with the reusable simulation design approach the researcher was able to come up with a simulation activity relevant and appropriate to the South African situation, namely the 'Coal or Nuclear' simulation activity.

The questionnaire technique was established as the most applicable method for the assessment of the effectiveness of a simulation activity. An appropriate questionnaire was then designed accordingly.

After pilot testing both the simulation activity and questionnaires, and then refining them, the 'Coal or Nuclear' simulation activity was ready to be conducted in the schools.

It must be pointed out at this juncture that although it was the desired objective of the researcher to achieve an anti-nuclear stance among the pupil sample, the means of achieving this change was not to be through indoctrination, but rather through personal choices based on the pupil's experience of this issue through a simulation activity. This view, according to the researcher, is founded on the premise that all, or the majority of the pupil sample would be unsure, indifferent or pro-nuclear in their regard to this environmental issue. This assumption was based on the researcher's involvement in organisations such as Koeberg Alert and the Cape Town Ecology Group.

After conducting the research programme the signs were indeed encouraging in that the pupils appeared to have enjoyed the learning experience while a quick survey of the results of the three questionnaires indicated that some anti-nuclear changes might have occurred.

CHAPTER SIX

OVERALL OBSERVATION OF THE APPLIED RESEARCH

6.1 THE 'COAL OR NUCLEAR' SIMULATION ACTIVITY IN OPERATION IN THE EIGHT CAPE EDUCATION DEPARTMENT SCHOOLS.

The following is a school by school description and analysis of the actual operation of the 'Coal or Nuclear' simulation activity. The identity of each school and every pupil remains anonymous in accordance with an instruction from the Cape Education Department (see Appendix 9). The time allocated for each session and break at all of the eight schools visited was identical.

SCHOOL NO: **ONE**

VENUE: **SCHOOL GYM HALL**

Report on the Briefing session:

On mentioning that they (the pupils) would be taking part in a simulation activity only one pupil indicated that he had previously (at another school) experienced this particular teaching method.

The operating instructions were given to the pupils without any apparent problems. The researcher then arranged the pupils into randomly selected groups, handing each group a file containing information for use during the activity (see Appendix 3). Some pupils asked whether they could be with their friends, however it was explained to them that, for the sake of objectivity the groups had to remain as they had been randomly selected. The pupils appeared to accept this explanation.

Report on the Action session:

There appeared to be much excitement at the prospect of beginning with the activity, because the groups immediately started the process of electing a leader and getting down to reading the information files and discussing the topic at hand. During this session some groups appeared to stop momentarily to try and hear what the other groups were saying, while one or two pupils actually left their groups to visit a friend in another group. When this was detected, the individual or group in question was told to come up with their own conclusions.

After a ten minute break each group gave their decision via their group leader as to whether they were in favour of a coal-fired or nuclear power station. It was evident that the pupils were entering into the spirit of the activity by referring to each other as Councillor, or Your Worship (when addressing the Mayor).

The outcome of the voting was as folows:

pro-nuclear station	-	2
pro-coal-fired station	-	4

Cheers of delight were heard from the pro-coal lobby when the result was announced by the Mayor.

Report on the Debriefing Session:

During this session the pupils did not always retain their roles and lapsed back into 'themselves' quite often. Most of the pupils seemed to indicate that they had enjoyed this particular way of teaching. One particular pupil raised the question as to how this particular way of teaching could be implemented in all subjects, especially mathematics.

Another pupil wondered why simulation activities were not used more often in their school.

SCHOOL NO: **TWO**

VENUE: **SCHOOL HALL**

Report on the Briefing session:

None of the pupils had ever experienced simulation activities before. The pupils listened to the operating instructions attentively. The same problem arose when the group selection was announced (as at school 1) with some pupils indicating that they would much rather be with 'x' rather than 'y', however they too accepted the researcher's explanation.

Report on the Action session:

The groups were soon buzzing with heated discussion, group members were actively seen agreeing and disagreeing with one another. One pupil was overheard to say "my father said that ......" in defence of his own argument. This statement appeared to indicate that some of the pupils were not maintaining their roles. A few pupils, as at the previous school, walked around during the group discussions. When the group report back session took place there was much heated and emotive argument for and against nuclear power stations.

The outcome of the voting was as follows:

pro-nuclear station	-	3
pro-coal-fired station	-	3

The Mayoress had the casting vote which gave victory to the pro-nuclear lobby.

Report on the Debriefing session:

The pupils had difficulty maintaining their roles, but quite openly and frankly expressed the view that they had thoroughly enjoyed the activity. One pupil went so far as to say that the whole activity should have been longer, because he felt that he was just starting to really enjoy the activity when it ended.

SCHOOL NO: **THREE**

VENUE: **CLASSROOM**

Report on the Briefing session:

None of these pupils had ever been exposed to simulation activities. The operating instructions and the random selection of groups posed no problems at this school. Some of the pupils did indicate that although they had never been taught by means of a simulation activity, they had done group work before.

Report on the Action session:

The pupils appeared at first not to be taking the activity seriously, because some of them entered into a series of light-hearted exchanges with their Geography teacher who had been present up to this point. He then, realising the consequences of his actions, apologised, told the pupils to settle down, and left the classroom. This was the first occasion at which a teacher from the school concerned had 'sat-in' during the action session.

This 'incident' meant that some time had been lost but the pupils did settle down soon thereafter.

This session produced some good debates and argument, however, some of the pupils were seen milling around ten minutes before the end, when approached they said that they had been given too much time. These pupils were then asked whether they had all read the information files, they replied yes, however, upon questioning it became clear that they had not done so.

After the ten minute break the result of the voting proved to be surprising.

Voting outcome:

pro-nuclear station	-	6
pro-coal-fired station	-	0

Report on the Debriefing session:

These pupils did not retain their roles at all but immediately reverted back to themselves.

The pupil who had played the Mayoress informed the researcher that the unanimous pro-nuclear result was, in her opinion, due to the fact that this entire class had recently been on a Science outing to the Koeberg Power Station, where they had all been told of the benefits of nuclear power.

Some pupils felt that it was a pity that the simulation activity could not have been done outside of school times, because an activity of such length might make them miss other lessons. Despite this the majority of the pupils did express the view that they had enjoyed the activity.

SCHOOL NO: **FOUR**

VENUE: **CLASSROOM**

Report on the Briefing session:

The co-operation and friendliness received by the researcher at the previous three schools was not evident at this one. On arriving at the pre-arranged classroom, the classroom was found to be locked. On opening it more time was wasted rearranging rather cumbersome desks by the uncooperative group of pupils. The unpleasantness climaxed with one of the pupils - who, on hearing that the researcher taught at a neighbouring school, said "why don't you go and do your research there?" The researcher defused the situation with self-control and by talking it through with the group.

The pupils explained that they were regarded by the staff as "the dumb" class and were "often required to do these sort of things", i.e. being research guinea pigs. Much of the Briefing therefore was given over to winning their confidence.

Report on the Action session:

The Action session, despite the earlier setback, appeared to have run smoothly with much discussion and debate. One group did come to the researcher after only twenty-five minutes saying that they had finished. It was clear that they could not have read through the files and discussed the issue at hand properly, so they were sent back to do the exercise as instructed. They did appear to comply with this instruction.

The outcome of the voting was as follows:

pro-nuclear station	-	5
pro-coal-fired station	-	1

Report on the Debriefing session:

The pupils immediately discarded their roles, some of them said that the exercise had been enjoyable and interesting, while others commented that they had experienced simulation activities before. After the class had been dismissed, a few of the pupils came to the researcher and apologised on behalf of their peers, indicating that they were sorry about what had happened.

SCHOOL NO: **FIVE**

VENUE: **CLASSROOM**

Report on the Briefing session:

The Briefing session went off without any problems, however, the researcher was now mentally more on guard than at the start of the research project, because of the experience at the previous school. Most pupils indicated that they had never before taken part in a simulation activity.

Report on the Action session:

The groups settled down quickly after electing their leaders. One group in particular individually read the information files for a long time and were very serious in the way in which they went about discussing the pros and cons of nuclear power.

The pupil playing the part of the Mayor decided on his own to go around and visit each group. One pupil was seen reading a novel during the discussion time until she realised that the researcher had seen her. Another pupil remarked on reading a newspaper article (contained in the information files) headed "Koeberg plan an economic disaster" (Appendix 3) that "this is all against Koeberg".

The researcher in answer explained that the files contained both information for and against nuclear power, and that he was free to disagree with it. The outcome of the voting was as follows:

pro-nuclear power station	-	4
pro-coal-fired power station	-	2

Report on the Debriefing session:

The pupils at this school did consciously try to retain their roles, but they seemed to find it difficult. The reason for this was most likely due to the lack of exposure and practice in the art of role-playing.

Some pupils did indicate that they were bored during aspects of the reading, however, that when the discussion and debate started, they began to enjoy the simulation activity. The large majority of pupils said that they had really enjoyed the activity, especially the topic. This last point was confirmed by one of the parents (a mother who worked as one of the school secretaries) the day after the simulation activity when she told the researcher that the debate and discussion had continued at their house with her son and some friends ending up with a family discussion that night. This, albeit isolated incident, was gratifying and an interesting development for the researcher, because it highlighted the possible effects of exposure to this particular method of teaching, and the need for future research in this area became evident. This incident also raised the point that evaluation of the effects of the simulation activity might go beyond the classroom experience.

SCHOOL NO: **SIX**

VENUE: **CLASSROOM**

Report on the Briefing session:

The pupils were relaxed and keen to take part in the simulation activity, although none of them had previously been exposed to one. Once the formalities of instructions and pre-arranged groups had been set up, the activity began.

Report on the Action session:

The group work started off well, however, there were isolated incidents, possible boredom and reluctance to read all the information in the files. On the other hand, one of the members of the Management Committee, on his own initiative, visited each of the groups with the express purpose (retaining his role all the time) of bribing them. He did so, secretly (without informing the researcher) telling them that they (i.e. each group) would receive R100,000.00 if they voted in favour of his proposal, when the time came to put forward their individual decisions on the building of a nuclear or coal-fired power station. This "scandal" was only exposed when one group made public what had happened. As a result of the 'bribery' (some groups accepting, others not) the Management Committee at this school narrowly defeated the rest of the groups (due mainly to the casting vote held by the Mayor) in this instance, by six votes to five. The additional series of events thus came about as the result of this innovative action of one particular pupil who quite obviously really entered into the spirit of the simulation activity, and carried the rest of the pupils with him. This incident (not that dishonesty is encouraged) conjures up the hope that, with greater use, the simulation method could become a valuable teaching technique, especially where environmental education is concerned.

The outcome of the voting was as follows:

pro-nuclear power station - 1

pro-coal-fired power station - 5

Report on the Debriefing session:

The pupils indicated that they were glad that they had been part of such an exercise and expressed the desire to experience simulation activities in their own school in the future. Many pupils expressed the need for more young South Africans to become environmentally educated.

SCHOOL NO: **SEVEN**

VENUE: **SCIENCE LABORATORY**

Report on the Briefing session:

The pupils were keen and co-operative however, it was physically difficult to break up into groups because of the fixed laboratory benches.

Report on the Action session:

Although the pupils were keen and went about their tasks, there were continual interruptions because of Science teachers and laboratory assistants walking in and out of the room to fetch equipment and chemicals (the science store room happened to be situated in the classroom allocated to the researcher).

Despite the disruptions the pupils continued with the activity. Some of the discussions became so heated that 'visiting' teachers stopped to listen.

The outcome of the voting was as follows:

pro-nuclear power station - 4
pro-coal-fired power station - 2

<u>Report on the Debriefing session</u>:

All the pupils indicated that they had enjoyed the exercise, but they had felt that the venue was not conducive to such an activity. They also expressed the view that maybe more time was needed for the Action component.

<u>SCHOOL NO:</u> **EIGHT**

<u>VENUE:</u> **CLASSROOM**

<u>Report on the Briefing session</u>:

These pupils were responsive and co-operative from the start. They also expressed an interest in environmental problems, in particular acid rain and other forms of air pollution. They wasted no time in getting into their groups and electing their leaders.

<u>Report on the Action session</u>:

The readings and the discussions went well and there was much activity in the individual groups. Once again, however, there was evidence to suggest that not all of the pupils were reading the information files thoroughly enough. This suspicion was confirmed when listening to the groups and hearing pupils presenting arguments either pro or anti something which was too emotional and not based on enough supportive evidence. The results of the voting were as follows:

pro-nuclear power station - 4
pro-coal-fired power station - 2

Report on the Debriefing session:

The general consensus among these pupils was that they had enjoyed the simulation activity, however, they too felt that they did not have enough time for the Action component. Some pupils indicated that they would try to improve their environental awareness by reading up on it.

6.2 POST-HOC OBSERVATIONS OF THE APPLIED RESEARCH

The following are general observations of the simulation activity and questionnaires in action:

(a) according to pupil feedback from questions 57 and 58 of the questionnaire and supporting verbal comment the majority of the pupils appear to have had little or no experience with simulation activities;

(b) the major challenge associated with the implementation and use of the simulation method in the present education system in South Africa lies with the difficulty in doing the cross-curricular EE projects. The present rigid, single-subject emphasis of the school curriculum will always create difficulties, because it does not easily allow for the implementation of cross-curricular projects, so necessary in a values education approach. However, this does not mean that teachers in individual subjects cannot integrate EE into their particular subjects.

More specific observations made in connection with the "Coal or Nuclear" simulation activity were as follows :-

(a) the majority of pupils appeared reluctant to read all the material contained in the files provided (despite the material being reduced as a result of the pilot study). Perhaps the material needed to be reduced further, or a coal/nuclear lesson prior to the simulation activity should have taken place. On the other hand, it was necessary to provide a fair amount of objective background material dealing with the nuclear issue, because of the perceived bias towards nuclear energy held by the majority of South Africans and the complex nature of the topic. This bias appears to be a result of minimal anti-nuclear opposition, other than the small and presently ineffectual Koeberg Alert Group. In the course of its use in teaching, a lead-in to the "Coal or Nuclear" simulation activity is imperative. The lead-in should present both sides of the nuclear debate so that pupils could formulate their own opinions on this issue, rather than be indoctrinated with only one point of view. Evidence of sources of bias in the view of nuclear energy was obtained while conducting the "Coal or Nuclear" simulation activity at one of the schools. During the debriefing, one of the pupils remarked that the reason for the vast majority of them being in favour of nuclear energy and the building of nuclear power stations was due to the fact that they had all recently been on a science outing to the Koeberg Nuclear power station. There they had been reassured that nuclear power was safe, clean (in terms of pollution), cheap and the answer to South Africa's future energy requirements. The disturbing point educationally is not that they visited Koeberg, but that the pupils were not exposed to any anti-nuclear viewpoints before or after the outing. The result is that, when they had to make a decision regarding nuclear energy during the "Coal or Nuclear" simulation activity, most of them already had preconceived opinions in favour of nuclear power. This point is further evidenced by a remark made by a pupil at another school who stated, upon reading one of the local Cape Town newspaper clippings (included in the pupils' information files), that "this is all against Koeberg ...". Thus it can be postulated that, because of their inherently biased pro-nuclear points of view, many of the pupils refused or did not attempt to read the material contained in the files. Instead they launched into the discussions with very little reading and understanding of the issues.

(b) the pupils appeared to enjoy the feedback section in the action component possibly because, they now had an opportunity to voice their group's and their own points of view regarding the simulation activity. Once again, one was aware of the fact that on the whole, pupils both for and against nuclear power could not really provide convincing arguments, due to their apparent lack of knowledge on the subject. The pupils' arguments therefore tended to be too emotional. The researcher therefore believes that this particular environmental issue, and probably many others, need to be explored more fully in secondary schools, if the country hopes to deal adequately with and understand environmental problems in the not too distant future.

(c) there was evidence to suggest that a few pupils were relatively disinterested. One particular case was noted when, during the group reading session of the action component, a pupil read a paperback quite openly and unperturbed. Another incident was the open aggression and general uncooperativeness initially displayed by the pupils of one particular school.

After the researcher had introduced himself, a pupil remarked "... seeing that you come from that particular high school, why don't you go and conduct your research there ?" Despite this initial resistance which was minimal, the research went off quite smoothly without any further confrontations or uncooperativeness.

(d) on the other hand there was strong evidence to suggest that most of the pupils had enjoyed the entire exercise, because in every school visited there were numbers of pupils who willingly followed instructions, carried out duties properly, openly expressed their enjoyment to the researcher and even showed remarkable initiative themselves (or it could have been due to the novelty of the exercise).

(e) based on the accounts of the majority of pupils who took part in the 'Coal or Nuclear' simulation activity at the eight C.E.D. schools it appears that the exercise was successful, however it is understood that this is a superficial assessment. A more in-depth analysis follows in Chapter Seven.

6.3 POST-HOC OBSERVATIONS OF THE THREE QUESTIONNAIRES

In terms of the three administrations of the questionnaires, one observation was made in that a few pupils commented, on starting the second and third questionnaires, that these questionnaires appeared to be exactly the same as the first one. This recall might have encouraged them to attempt to reproduce their previous responses, rather than respond to the questions as was appropriate for that occasion. However no such trend could be identified before analysis.

The following chapter presents a statistical analysis of all the results.

CHAPTER SEVEN

COLLECTION, VERIFICATION AND ANALYSIS OF THE DATA

7.1 INTRODUCTION

After the first two questionnaires had been administered and collected, the data from each was transcribed onto specially drawn-up coding sheets. The data from the third questionnaire was tested differently. Instead of transcribing the data from the questionnaire onto coding sheets, and then onto computer data cards, it was decided to modify the final questionnaire so as to incorporate a column on the extreme right hand side of each page (Appendix 8(c)) in which the relevant data could be recorded (by the researcher after analysing each response). This process allows for greater convenience and diminishes transcript error.

7.2 ANALYSIS OF DATA

Two hundred and six respondents answered the first two questionnaires and one hundred and eighty-nine answered the final questionnaire, absenteeism (as mentioned earlier) accounting for the missing seventeen respondents.

For the purposes of this research, possible school differences were ignored, and the pupil sample was regarded as random and representative of White, English-speaking, Standard nine, Cape Education Department secondary school pupils. The researcher was aware that the sample was a convenience sample rather than a random sample of the (White, English-speaking C.E.D.) study population.

It is assumed that its structure will to some extent be representative of the pupils in the study population, and the sample is treated internally as if it were random.

Technically the inferences drawn here are valid for at least the pupils of the sampled schools.

Data analysis focused on:

(a) pupils' overall responses to fifty-six common questions (7 biographical, 9 environmental concepts, 9 environmental knowledge, 22 environmental attitudes and 8 behavioural intentions) in the questionnaires;

(b) four cumulative scores (Concepts, Knowledge, Attitudes and Behavioural Intentions) for individual pupils;

(c) changes over time associated with exposure to the simulation activity, as evidenced by differences in each of the fifty-four (9+9+23+8+4 totals) variables available for consideration.

To distinguish between the terms 'interval' and 'time point' the following distinctions (and Diagram 7.1) are made:

(a) interval - refers to the time period between time points, for example Interval 1 refers to the time period immediately before the simulation activity and directly after it.

(b) time point - refers to a specific point in time, for example, the administration of the first questionnaire immediately following the 'playing' of the simulation activity.

Diagram 7.1:

Diagram showing the distinction between a 'time interval" and a 'time point'.

```
+-------------------------------------------------+
|                        |                        |
| <----------------INTERVAL 3 -------------->     |
|                        |                        |
|                        |                        |
| <---INTERVAL 1 -----> | <---INTERVAL 2 ---->    |
|                        |                        |
+-------------------------------------------------+
 POINT 1                POINT 2                POINT 3
Simulation           Questionnaire          Questionnaire
Activity and
Questionnaire
```

The differences in responses were studied over three time periods or intervals:

(a) short-term learning during interval 1 between time points 1 and 2 i.e. between first and second (pre-and post-simulation) responses;

(b) drop-off in learning during interval 2 between time points 2 and 3; i.e. immediately after the simulation activity and a period of between 5 and 10 weeks; and

(c) the long-term change in learning during interval 3 between time points 1 and 3 i.e. between pre-simulation activity responses and those 5 to 10 weeks later.

For the individual constituent questions the essential focus of interest is on the changes through time in the responses. McNemar X^2-statistics (df=1) were obtained for each questionnaire item at each of three time intervals. A significant McNemar X^2-statistic indicates that changes have occurred in the general pattern of responses. In this study such statistics imply evidence of shifts of opinion on the corresponding item through the time interval concerned.

Beside these overall features, possible differences associated with gender and with subject choice, were also explored. The comparisons within these subgroups defined by the variables gender, Biology, Geography, Mathematics, Physical Science, Maths/Science, Biology/Geography are invariably exploratory because each subgroup defined by these criteria simply involves an implicit assumption that the other subgroupings do not intrude severely into the comparisons.

When subgroups of the respondents (gender and subjects) are analysed, comparisons are effected by Pearson X^2-statistics for the differences of score frequencies across groups.

The analyses were conducted by using computer programmes available in the BMDP series on the Univac mainframe computer at the University of Cape Town (U.C.T.). The run streams used in the analyses are provided in Appendix 10.

A five percent level of significance was used in the statistical analysis. A five percent level of significance is a commonly used standard of assessing statistically significant change. It indicates that the researcher is prepared to accept a maximal error rate of five percent in all comparisons that arise between two equivalent source groups of sample measurements, in mistakenly declaring them different. There is an expectation that when the sample source groups are truly different they will have a high chance or probability of being declared different by this method. Such probabilities are called the power of the statistical test, and power increases as sample sizes increase.

Power is also an increasing function of the size of the difference between the groups relative to the variability of the measures. Thus as groups diverge more, or as the groups become internally more alike in measurement, the power to distinguish between them is increased.

The repeated use of a 5 per cent significance level in many hundreds of comparisons requires further comment. If each of the comparisons were independent and unrelated to any of the others, one would expect approximately 5 per cent of all equivalent group comparisons to result in statistically significant differences. Consequently one needs to be satisfied that the observed number of statistically significant results will substantially exceed 5 per cent of the number of comparisons, before inferring that differences exist.

Alternatively, one might adopt a more conservative approach. One can declare an experiment-wise error rate of 5% and compare the usual statistics with greatly increased critical values from statistical tables. The rationale of this approach is to operate on the basis of having only a 5 per cent chance of declaring any one (or more) of all the equivalent groups different, and a 95 per cent chance of declaring all the equivalent groups to be equivalent.

This procedure is likely to ignore all but the most extreme actual sample differences existing between groups.

Accordingly in this study, the repeated 5 per cent significance level is applied, and the foregoing conditions are implicit in the discussions.

Attention will be drawn to sections of tables in which more significant values of test-statistics occur than all expected under use of the 5% level.

Where some overall change (over time) or difference (between groups) occurs on total scores for a category of items (e.g. Biology pupils obtaining a significantly higher total score than non-Biology pupils in the attitudes section) then additional remarks are made on any significant item changes or differences occurring within that category (e.g. Biology pupils scored higher on nuclear/coal items, but were not different from the non-Biology pupils on 16 of the 23 items in the attitudes section).

7.3 THE SCORING CRITERIA

The first eighteen questions (Concepts and Knowledge sections) involved the pupils choosing one of four possible categories. Each pupil scored a point for each correct answer, and zero for a false answer. The remaining questions were different in that they involved the pupils choosing one of five possible categories. Pupils were scored according to their particular choices made on an ordinal scale, in relation to a subset of the 5 responses subjectively designated to be correct by the researcher. These subsets were defined for thirty-one attitude statements (32 in the first questionnaire). Table 7.1 reflects the attitude statements, and the (subjectively) correct answers:

TABLE 7.1 Designated Correct Attitudes

SA A U - Strongly agree, agree and uncertain
SD D U - Strongly disagree, disagree and uncertain

Attitude statement	Desired Answers	Score in relation to ordinal scale
1. Nuclear power is dangerous	SA A U	5,4 or 3
2. Nature reserves must be protected	SA A U	5,4 or 3
3. Coal-fired power stations produce too much air pollution	SA A U	5,4 or 3
4. Nuclear power is a valuable technological development	SD D U	1,2 or 3
5. The continued use of coal in South Africa as an energy source is necessary	SA A U	5,4 or 3
6. Preserving old buildings is a waste of tax-payers money	SD D U	1,2 or 3
7. The conservation of historic urban areas is important	SA A U	5,4 or 3
8. In environmental/conservation issues people are more important than animals	SA A U	5,4 or 3
9. The exploding population is the greatest environmental problem facing the world	SA A U	5,4 or 3
10. Minerals found in nature reserves should be exploited	SD D U	1,2 or 3
11. Our growing electricity needs depends upon the use of nuclear power	SD D U	1,2 or 3
12. The 'population' explosion only pertains to particular countries.	SD D U	1,2 or 3
13. The need for environmental conservation is not as important as the need for economic development	SD D U	1,2 or 3
14. Recycling waste products is essential in today's world	SA A U	5,4 or 3
15. Nuclear wastes cannot be safely stored	SA A U	5,4 or 3
16. Whales must not be allowed to become extinct	SA A U	5,4 or 3
17. South Africa needs nuclear weapons for defence purposes	SD D U	1,2 or 3
18. Science and technology will solve all our problems	SD D U	1,2 or 3
19. Pollution is an acceptable price to pay for progress	SD D U	1,2 or 3
20. Our present lifestyle is the cause of the 'environmental crisis'	SA A U	5,4 or 3

21.	Littering is a serious environmental problem	SA A U	5,4 or 3
22.	Environmental problems will only by solved by the complete political restructuring of society	SA A U	5,4 or 3
23.	Alternative energy sources (eg. solar power) must replace the coal, oil and nuclear options	SA A U	5,4 or 3
24.	I am considering joining an environmental/conservation group (even if I am already a member of one particular group)	SA A U	5,4 or 3
25.	School pupils cannot do anything against large organizations or government bodies	SD D U	1,2 or 3
26.	I intend reading and finding out more about environmental problems	SA A U	5,4 or 3
27.	School pupils cannot be expected to do anything about environmental issues such as the nuclear issue	SD D U	1,2 or 3
28.	School pupils should give up one Saturday a month to help pick up litter	SA A U	5,4 or 3
29.	I would be willing to give money towards an environmental/conservation project	SA A U	5,4 or 3
30.	I will encourage people not to support the building of a nuclear power station	SA A U	5,4 or 3
31.	I would be willing to take part in a demonstration against a company found guilty of polluting the environment	SA A U	5,4 or 3

A zero-one scoring system was then applied, in which a score of one was allocated to that response designated correct by the researcher, and a score of zero to an incorrect response. Two way tables of frequencies of zero-one responses were constructed, and a corresponding array of 49 McNemar X^2 (dF=1) statistics was derived for each of the 3 intervals described in Diagram 7.1.

For each pupil at each time period, total scores were obtained for each of the four sections. The minimum total scores were all zero and the maximum scores were 9, 9, 23 and 9 for each section. Measures of the changes within a group in scores over the three time intervals were based on the above scoring system. McNemar

X^2 statistics were derived and large values indicate apparent changes in the distributions of scores over time.

Totals were allocated variable names as shown in Table 7.2.

Table 7.2. Variable names for totals at time points and during intervals

	Names for totals for individuals at time points			Names for total of changes in response during intervals		
	1	2	3	1	2	3
Concepts	CG10	C2CG10	C3CG10	D1C10	DC2C10	DC3C10
Knowledge	KG10	K2KG10	K3KG10	D1K10	DK2K10	DK3K10
Attitudes	AG33	A2AG33	A3AG33	D1A33	DA2A33	DA3A33
Behavioural intentions	AG34	A2AG34	A3AG34	D1A34	DA2A34	DA3A34

On each of the 4 sub-scales concepts, knowledge, attitudes and behavioural intentions, nine categories of score total were defined and the resulting 9 x 9 two-way table of frequencies of total score categories was subjected to analysis.

Total score changes are evidenced by the off-diagonal elements in such tables. This analysis focuses on changes in the overall distribution of the total scores for each of the 4 sub-scales, and McNemar's X^2 - statistics with 36 degrees of freedom were calculated. These statistics correspond to the last 4 lines of Table 7.3.

Significant values indicate evidence of total score changes. The direction of change is inferred by examining the body of the frequency table. The totals for changes in an interval are derived from entries -1, 0 and 1 (differences of 0,1 scores). Initially it is of interest to test whether the observed average differences (over time) are close to or different from zero. However, it is also possible to compare time differences between two groups (e.g. male and female). These tests use Pearson X^2 statistics with degrees of freedom 1 and 2 respectively.

The particular features of the data that emerged as being significant (at the five percent level of significance) are summarised in tabular forms (see Tables 7.3, 7.5, 7.6, 7.7, 7.8, 7.15, 7.22 and 7.29), but also appear in Appendices 11 - 26.

7.4 ANALYSIS OF SIGNIFICANT CHANGES OVER TIME

Table 7.3 represents a summarised version of all the significant changes in responses (whether positive or negative) which occurred within the complete set of responses over the three time intervals. The columns are divided into four sections which represent the corresponding divisions in the questionnaires (i.e. concepts, knowledge, attitudes and behavioural intentions). Three separate sets of columns depict the individual significant changes that have taken place over the corresponding time interval as evidenced by large values of McNemar's X^2). The symbols '+' and '-' describe whether the significant change was positive or negative in the researcher's view.

TABLE 7.3 - SIGNIFICANT VALUES FOR OVERALL "CHANGES" THROUGH TIME

		INTERVAL 1		INTERVAL 2		INTERVAL 3	
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No
	1	+	+				+
C	2				-		-
O	3						
N	4	+	+	-			
C	5				-		-
E	6						
P	7						
T	8			-	-		
S	9			+	+	+	+
	10	+		-		-	
	1	+	+				+
K	2	+	+				+
N	3	+	+	-	-	+	
O	4						
W	5	+	+				+
L	6	+	+	-	-		+
E	7	+	+		-	+	+
D	8	+	+	-	-	+	
G	9	+	+			+	+
E	10	+		-		+	
	1						+
	2						
	3	+	+				+
	4	~					
	5	-	-		+		+
	6	-			-		-
	7	~			+		+
	8				+		+
A	9						+
T	10		+		-		~
T	11		-		-		-
I	12	+	+		-		-
T	13				-		-
U	14						
D	15		+				+
E	16				-		-
S	17	+	+		-		-
	18	~			-		-
	19						+
	20						
	21				+		+
	22						+
	23	+	+				
B I							
E N	24				-		-
H T	25				-		-
A E	26	+	+				
V N	27	+	+		-		
I T	28	+	+				+
O I	29		+		-		
U O	30						
R N	31	+	+				
A S	32						
L							
Concepts							C3CG10+
Knowledge							
Attitudes							
Beh. Int					A2AG13-		A3AG34+

Entries in the columns headed 'category' indicate whether or not there were significant changes or movements in the pattern of the respondents' responses to particular items between one and another. Such movements were positive or negative in accordance with the judgement of the researcher. The symbol '~' indicates that some statistically significant movement took place, but was either not of a type or not sufficient to be designated positive or negative by the researcher.

Entries in the columns headed 'Yes/No' indicate any significant changes in the response pattern from right to wrong answers or vice versa. A positive sign indicates there was movement to the response designated by the researcher as appropriate or correct
from responses designated as inappropriate or incorrect. Equivalently a larger proportion of respondents chose the correct category. A negative sign indicates the converse.

A significant result for the categorical information, if not accompanied by a significant result for the corresponding 'Yes/No' category, may indicate the existence of alternative patterns of confusion amongst respondents to the corresponding items.

Cochrane's Q statistic may be applied to the 0-1 scores on individual scale items over the three time points. The Q-statistic would be derived from the 189 x 3 (complete cases x time points) tables of 0 - 1 scores on any given scale item from the 49 items, and large values of Q would indicate differences through time on that individual item. Such differences might be interpreted as the results of the simulation experience, but because the researcher's interests lay in the possible existence of short-term, drop-off and long-term effects, analysis of actual differences between scores on individual items at pairs of time points, was preferred. These pairs correspond to the intervals 1, 2 and 3 respectively of the tables.

All three time intervals are collectively important in making an assessment of the success of the simulation activity. Columns two, four and six in Table 7.3 represent the significant changes in the overall scores between time points 1 - 2 (short-term effects), 2 - 3 (drop-off rate) and 1 - 3 (the long-term effects).

In Table 7.3, Interval 1 is important because it covers the period between the first occasion just before the simulation activity, through the simulation activity, to the second occasion just after the simulation activity. The interest in this time interval is in being able to identify whether short-term learning has taken place as a direct result of exposure to the simulation activity. Interval 2 on the other hand is valuable in establishing the expected drop-off in learning between the second and final occasions. Lastly, Interval 3 indicates any long-term learning which took place between the first and the last occasions on which the questionnaire was administered.

A closer examination of each of the three time intervals follows (focussing on the results of the Yes/No columns i.e. columns 2, 4 and 6). In some cases a Yes/No column entry will appear without a corresponding category column entry. This phenomenon implies that change in pattern is not statistically detectable until one defines a binary set of correct/incorrect response categories. For example, small decreases in proportion at each inappropriate response which had a corresponding increase for the correct response may exhibit this effect, as a result of the aggregation. When a category column entry appears without a '+' or '-' in the adjacent Yes/No column for the same time interval, there is a suggestion that changes have occurred but represent different patterns of confusion (moving from one inappropriate or incorrect response to another). For each interval, subject and question a measure of change was constructed: a later score minus an earlier score (each either wrong = 0 or correct = 1), with the final result being either 1, 0 or -1 (1 = positive change, 0 = no change, and -1 = negative change).

7.4.1 **Interval 1 and Initial Changes**

The most notable feature of Interval 1 is the number of positive responses which were recorded in the environmental knowledge and behavioural intentions columns. These results are promising, in that they suggest learning has taken place. One may assume that the simulation activity brought about these changes, because the second questionnaire was administered immediately after the simulation activity, thus preventing any other factors from interfering with the effects of the simulation activity.

Despite favourable results in the knowledge and behavioural intentions sections, the short-term results for the attitudes and concepts sections were disappointing for the researcher, because most of the changes were expected to occur in the latter two sections. Fewer changes either negative or positive in these sections may be a consequence of the fact that both concepts and attitudes fall into the realm of the abstract, while elements of knowledge and behaviour are possibly more clearly and easily understood and remembered. Changes (whether negative or positive) which took place in the attitudes section are adjudged against the subject views of the researcher who decided how each attitude and behavioural response on a predetermined ordinal scale should be scored. These presuppositions (of the researcher) were taken into consideration when analysing the results, particularly of the eight attitude statements relating to nuclear or coal-related issues, in the attitudes section.

Closer scrutiny of the attitudes results in Table 7.3 reveals that pupils improved scores on four out of the eight nuclear-coal related statements (numbers 1, 3, 4, 5, 11, 15, 17 and 23) and obtained lower scores on two items, indicating a short-term move towards an anti-nuclear stance after exposure to the simulation activity. The only nuclear-coal related statement not to show any significant change during this period was number 1. Thus, an initial impression of an apparent lack of change in the attitudes section can be largely dispelled.

The other point of interest which emerged in the attitudes section, was that the statements for which significant changes did not appear in the results, were those not directly related to the simulation topic at all. This finding provides further confirmation that the simulation activity is a means of affecting attitudinal short-term changes for the issues that it addresses.

An overall assessment of the Interval 1 results is that the simulation activity performs satisfactorily and is effective in inducing short-term learning relating to knowledge, attitudes and behaviour.

7.4.2 Interval 2 and the Drop-off Effect

During Interval 2 a marked drop-off occurs in the learning which took place in Interval 1. Previous positive results in the knowledge section are followed by a number of negative changes. The same pattern is observed in the behavioural intentions section. In the attitudes section four out of the eight nuclear- coal statements show change, three of which are negative. Although there are in this time period more attitude statements with significant change than interval 1, they are mostly negative.

The concepts section displays one rather interesting result in that the ninth question, the only one dealing with the nuclear issue, now emerges with a positive score. This positive score change (on average six and a half weeks after the simulation activity) is somewhat puzzling, unless this particular issue (relating to radio-active half life) was influenced in or out of the classes in all schools during the period between the simulation activity and the last questionnaire. This however appears to be unlikely and yet inexplicable, or by chance alone.

As expected, there appears to be a significant drop-off in learning between the second and third occasions on which the questionnaires were administered. This change is possibly due to a lack of sustained exposure to the nuclear-coal related issues that were experienced in the simulation activity.

7.4.3 Interval 3 and Long-term Change

During Interval 3, a pattern of results similar to that for Interval 1 is encountered. The knowledge component displays an overall positive score, although slightly less than during Interval 1 (viz. all the questions except number 4 showed positive changes during Interval 1, while in Interval 3 there were three questions, numbers 3, 4 and 8 which showed no significant change).

The attitudes section again exhibited a significant move towards an anti-nuclear position, with five out of the eight identified nuclear-coal related attitude statements again recording positive score changes (i.e. attitude statements 1, 3, 5, 15 and 23). However, only three of these (i.e. 3, 15 and 23) had previously shown positive scores during Interval 1.

TABLE 7.4: Nuclear/coal-related attitude statements which reflected significant changes in score within Intervals 1 or 3

Attitude Statements	Interval 1 (short-term)	Interval 3 (long-term)
1. Nuclear power is dangerous	0	+
3. Coal-fired power stations produce too much pollution	+	+
5. The continued use of coal in South Africa as an energy source is necessary	-	+
10. Minerals found in nature reserves should be exploited	+	0
11. Our growing electricity needs depend upon the use of nuclear power	-	-
15. Nuclear wastes cannot be safely disposed of	+	+
17. South Africa needs nuclear weapons for defence purposes	+	-
23. Alternative energy sources (eg. solar power) must replace coal, oil and nuclear options.	+	+

- = significant change (negative)
0 = no significant change
+ = significant change (positive)

It is of interest to note that attitude statement number 1, which refers to nuclear power being dangerous, only elicits a positive score at this late stage (i.e. interval 3). The attitude statement (number 17) that deals with South Africa requiring nuclear weapons for defence has moved from an initial significant anti-weapons change (Interval 1), to an overall negative change favouring nuclear weapon development.

Of note is the emergence of additional positive attitude changes on five statements i.e. numbers 7, 8, 9, 20 and 22. These five statements are related to other aspects of the environmental crisis. This broadening in itself is significant, because, it is an indication that in the long-term the simulation activity (possibly in conjunction with discussion, prompted by exposure to the simulation activity) can be said to be promoting a holistic approach, which is, in the view of this author, a crucial aspect in the understanding of the human-environmental crisis.

The concepts section exhibits four changes (i.e. two positive and two negative). As in Intervals 1 and 2, less than fifty percent of the questionnaire items exhibit significant change. The positive change recorded in Interval 2, with regard to the nuclear-related question (number 9) dealing with the term 'radio- active half-life', continues.

Some lack of change in the concepts section (in contrast to the knowledge section) could be due to pupils reading the information files superficially during the simulation activity. It has been contended that the files may have contained too much information, resulting in the pupils' being very selective and narrow in their choice of reading. However, this explanation is not entirely satisfactory, as the results from the knowledge section apparently imply the contrary. The files also had to be read in order to discover the correct answers for the knowledge section. During Interval 1 an almost uniform positive change occurred, with only question 4 showing no significant change. Interval 2 predictably shows a large drop-off in positive changes. Interval 3 displayed a number of significant long-term positive changes, with the exceptions of knowledge items 3, 5 and 8.

In the behavioural intentions section, there are fewer positive changes. The drop-off, first recorded during Interval 2, appears to be an overall phenomenon. These facts are possibly an indication that the further removed the pupils are from the experience of the simulation activity (in terms of time), the less inclined they are to change their environmental behaviour patterns either negatively or positively.

7.4.4 Significant Total Scores for the Various Sections

During interval 2 there was a marked drop-off in the average individual total behavioural intentions scores (A2AG34) of the pupils. Through the entire study period there is an improvement in the average individual total concepts and behavioural intentions scores (C3CG10 and A3AG34).

This phenomenon is interpreted as a consequence of the simulation activity, but there is not necessarily proof of this assertion in this study.

7.5 OVERVIEW OF THE OVERALL CHANGES BROUGHT ABOUT BY THE SIMULATION ACTIVITY

In relation to the general advantages and disadvantages associated with simulation activities (Table 4.3) the overall results show that the simulation activity was successful:

(a) in conveying knowledge and affecting pupils' attitudes (in the short and long-term); and

(b) in influencing (what were considered) positive behavioural actions towards the environment and environmental issues.

However, despite these successes, the simulation activity was apparently unable satisfactorily to transform the pupils into adopting an anti-nuclear position, which was the desired objective sought by the researcher. The choice of this particular environmental issue could quite easily have been replaced by an alternative from a number of issues e.g. protecting a nature reserve or studying the environmental impact of a housing development. This outcome suggests that it is more difficult to attain specific objectives pertaining to one particular issue, rather than overall objectives relating to broader issues. However, the outcome might also be considered as positive suggesting that simulation activities may not easily be used for indoctrination, but rather as a means of allowing pupils freedom of thought and expression, thus reinforcing democratic principles. The importance of such a teaching technique for a changing South Africa may be invaluable. The inability of the simulation activity satisfactorily to convey environmental knowledge during Interval 2, is an indication that there is a need for supportive and follow-up activities, to reinforce what may be experienced during the simulation activity.

In practice such a conclusion implies that the simulation method should be complemented with other teaching methods, and should not merely be used as an isolated teaching technique.

7.6 GENDER DIFFERENCES THROUGH THE STUDY

7.6.1 Introduction

There were 114 males in the study group compared with 92 females. Significant gender differences observed at the three time points or over the three time intervals are summarised in Table 7.5.

In Tables 7.5 - 7.8, 7.15, 7.22 and 7.29 columns 2, 4 and 6 are different from the corresponding columns of Table 7.3 in that they represent significant differences between the groups as observed at different time points (e.g. the differences between males and females at time point 1). Columns 7, 8 and 9 refer to any significant change in the differences between time points (e.g. sex differences at time point 1 minus the sex differences at time point 2).

In order to use Table 7.5 (and similar tables with the same basic format), it is necessary at this juncture to describe that format:

(a) the table is divided into five horizontal sections, representing environmental concepts, knowledge, attitudes and behavioural intentions (with their corresponding question numbers) and the total scores;

(b) the first six vertical columns are divided into three sets of two, each set corresponding to a specific time point, (viz. those at which the questionnaire was administered). Within each set, one column is used for overall gender differences in the patterns of category responses, and one for overall gender differences in average scores (based on the required answer choice). Thus columns 1, 3 and 5 focus on categories, but columns 2, 4 and 6 on the correct/incorrect (yes/no) answer choice.

(c) the last three vertical columns are each associated with significant changes in gender differences during specific time intervals, (viz. D1C = changes in gender differences between time period 1 and 2)

TABLE 7.5 - SIGNIFICANT VALUES FOR VARIABLE GENDER

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1							+	+	
C	2			-	-				-	
O	3									
N	4									
C	5							+		
E	6				-					
P	7									
T	8									
S	9	+	+		+				-	-
K	1								-	
N	2	+	+					-		-
O	3									
W	4	-						-		
L	5									
E	6									
D	7									
G	8			+	+		+			
E	9									
	1									
	2									
	3	-	-							
	4	-	-		-	-	-	~		+
	5	-	-			-	-			
	6	-	-	+					-	
	7	+		+						
	8									
A	9			+						
T	10									
T	11	+								
I	12									
T	13									
U	14							-		
D	15	-	-							
E	16									
S	17	+								
	18									+
	19									
	20									
	21									
	22									
	23	+	+					-		-
B I										
E N	24		-			-	-			
H T	25									
A E	26		-							
V N	27						-			
I T	28	-	-	-	-	-		-		
O I	29					-	-		-	-
U O	30	-	-	-	-					
R N	31									
A S	32									
L										

Concepts	CG10+	C2CG10+
Knowledge		K2KG10+
Attitudes	AG33-	
Beh. Int	AG34-	A2AG34+

In Table 7.5, for columns 2, 4 and 6, the '+' symbol refers to the significant differences with higher average scores by males, while the '-' symbol refers to those with higher average scores by females. The absence of a symbol indicates that no evidence of significant gender differences emerged for the corresponding questions. Similarly for columns 7, 8 and 9 the '+' symbol indicates males who underwent significantly more change than females and so on.

Tables of Pearson X^2 values (calculated for differences between groups e.g. Maths vs Non-Maths and not for the complete group) corresponding to the summarized versions of tables 7.5, 7.6, 7.7, 7.8, 7.15, 7.22 and 7.29 appear in appendices 13 to 26.

The summarised versions are presented for simplicity to indicate the number and extent of significant changes detected in the available differences. Degrees of freedom for the X^2 values vary between one for individual item frequency tables and eight for the total score tables.

7.6.2 Evaluation of the Gender Difference Results

An overview of all the Yes/No results for the three respective time points indicates that the female group displayed superiority in terms of the scoring on nineteen items (covering all four categories) while the males only showed superiority on six.

Closer scrutiny of these results shows that

•

At time point 1 (before the simulation activity) :-

Males showed significantly higher average scores than females in two questions in the concepts and knowledge categories (i.e. concept question number 9 and knowledge question number 2). These results might be interpreted as indicating that before the simulation activity males were marginally superior to the females in terms of nuclear concepts and knowledge (both questions were related to nuclear issues).

In contrast the female group displayed higher average scores in five of the attitude statements (i.e. numbers 3, 4, 5, 6 and 15), versus one for the males (number 23). As attitude statements 3, 4, 5, 15 and 23 are all related to nuclear/coal-related issues, it can be postulated that in respect of anti-nuclear environmental attitudes (deemed to be desirable by the researcher) the female group was significantly superior to the male group before the simulation activity.

In the behavioural intentions sections females display a significant superiority over males in respect of higher average scores recorded for statements 24, 26, 28 and 30. Before the simulation activity the female group displayed a greater apparent willingness to become actively involved in environmental issues and in particular nuclear issues (e.g. statement 30 declares an intention to encourage other people to oppose the building of a nuclear power station).

At <u>time point 2</u> (Directly after the simulation activity):

Females show a significant superiority in the concepts section (with higher average scores for questions 2 and 6) while males again displayed superiority in question 9. In the knowledge section males show a single significantly higher average score in question 8, which is a nuclear/coal-related issue.

Females retain their superiority in the attitudes and behavioural intentions sections.

At time point 3 (i.e. between 4 - 10 weeks after the simulation activity) :-

> Males maintain some superiority in environmental concepts and knowledge, while females display superiority in the attitudes and behavioural intentions sections.

The last three columns indicate significant changes in gender differences during the three different time intervals.

During Interval 1 (short-term effects) the following significant changes in gender differences were noted:

In the concepts section the female group made significantly more progress than males in question 2, while males made superior progress in question 5. However, females show dominant progress for the rest of the categories, in interval 1. The female group has a tendency to show greater short-term improvements than the male group.

During Interval 2 (i.e. the possible drop-off effect between time point 2 and 3) again males showed superior change in only one item (question 2 in the concepts section) while females showed relatively superior changes in concepts questions 3 and 9, knowledge question 1, attitude statements 14 and 23 and behavioural intentions statement 28. In summary negative drop-off effects are likely to be more marked among males.

During Interval 3 females show an overall superiority over males in the changes experienced.

In summary, Table 7.5 indicates that females tend to exhibit more changes that are positive in this researcher's terms, and that such changes are more likely to be long term than those of their male counterparts. The reasons for this could possibly be attributed to the present socialization patterns associated with males and females in Western society. However, these assertions are beyond the scope of this study and yet may provide an interesting area for further research.

7.6.3 Significant Total Scores for the Various Sections

Males tended initially to exhibit higher total individual scores on concepts (CG10) and lower scores on attitudes and behavioural intentions than females. At time period two males continue to show superiority in concept (C2CG10) and behavioural intentions (A2AG34) sections, and are also better in the total knowledge score (K2KG10).

These effects do not persist in time period 3 and there is no statistical evidence of changes in the time intervals differing across the genders.

7.7 DIFFERENCES THROUGH TIME ASSOCIATED WITH SUBJECT GROUPINGS

Another possible feature of interest is the relationship of responses to different school subject groupings. The breakdown of the number (and percentage) of pupils who took specific subjects or combinations of subjects is as follows:

Biology	(Table 7.6)	120 pupils	= 58,2%
Geography	(Table 7.7)	98 pupils	= 47,6%
Maths	(Table 7.8)	172 pupils	= 83,5%
Science	(Table 7.15)	123 pupils	= 59,7%
Maths and Science	(Table 7.22)	121 pupils	= 58,7%
Biology and Geography	(Table 7.29)	61 pupils	= 29,6%

Tables 7.6, 7.7, 7.8, 7.15, 7.22 and 7.29 are summarised versions of the various subject grouping analyses. These tables follow the same format as that for Table 7.5. The interpretations of the '+' symbol in each case indicates a significant positive effect of the subject in question on average score eg. in Table 7.6 - subject 2 (biology) the '+' symbol indicates that biology students scored higher than those not taking biology. The '-' symbol implies the converse.

These particular school subjects and subject combinations were chosen for analysis, because the researcher was of the opinion that pupils taking these subjects or combinations of subjects might exhibit interesting contrasts. However, as each pupil takes several subjects it is likely that the apparent effect of individual subjects or subject pairs are confounded with effects of other subjects.

7.7.1 Differences Associated with Biology

Table 7.6 shows the significant differences associated with respondents who studied Biology compared with those who did not.

TABLE 7.6 - SIGNIFICANT VALUES FOR VARIABLE SUB2 - BIOLOGY

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1	+	+			+	+	-		
C	2	+	+	+	+	+			-	
O	3									
N	4									
C	5									
E	6									
P	7									
T	8									
S	9		-	+	-				+	
K	1				-					
N	2		-	+	-		-			
O	3									
W	4									
L	5									
E	6			-	-			-		
D	7			-	-				+	
G	8			-	-			-		
E	9	~	+							-
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8							-		-
A	9									
T	10									
T	11	-								
I	12									
T	13	+								
U	14		+							
D	15	+	+	+	+					
E	16	+		~						
S	17									
	18									
	19									
	20									
	21									
	22									
	23		+				+	-		-
B I										
E N	24					-				
H T	25									
A E	26									
V N	27									
I T	28			+	+	+		+		
O I	29					+			+	+
U O	30									
R N	31									
A S	32									
L										

Concepts
Knowledge K3KG10- DK2K10-

Attitudes A3AG34+
Beh. Int

At Time Point 1:-

Biology pupils scored significantly higher on concept questions 1 and 2 (which relate to an understanding of the terms ecology and ecosystem), as one might expect. Biology students did not, however, score significantly better on questions 6, 7 and 8, which also related to specific biological terms (such as environment, food chain and habitat). Reasons for this phenomenon are not entirely evident, unless these particular terms had not at that time been covered in the Biology syllabus.

Non-Biology students scored significantly higher on concept question 9 and knowledge question 2 (both of which deal with nuclear/coal-related issues) than Biology pupils.

Biology pupils scored significantly higher on nuclear/coal-related questions in the attitudes section (i.e. numbers 15 and 23 in Table 7.6). There were no significant differences in the behavioural intentions sections.

Thus at time point 1, i.e. before the simulation activity, the Biology pupils appear to have had a slight advantage over non-Biology pupils when it came to interpreting biological terms, as might have been expected. However, other differences were too circumstantial to be of any note.

At Time Point 2:-

The Biology pupils continued to score significantly higher on concept question 2, while the non-Biology pupils maintain their superiority on concept question 9;

The non-Biology pupils scored significantly higher than the Biology pupils in the knowledge section (i.e. in questions 1, 2, 6, 7 and 8);

The Biology pupils again showed a significantly higher score on question 15 in the attitudes section, as well as a higher score in the behavioural intentions (i.e. question 28).

At time point 2, non-Biology pupils show a significant superiority in the knowledge section over the Biology pupils. The only logical explanation for this is that after exposure to the simulation activity, non-Biology pupils were able to do significantly better than the Biology pupils, for reasons that are as yet unclear. This phenomenon might be due to the fact that Biology is still a possible preferred option for weaker students i.e. in the current Physical Science vs Biology or Maths vs Geography subject choice pairings.

At Time Point 3:-

Biology pupils retain a significant superiority only in concept question 1 and attitude statement 23. The non-Biology pupils retain their superiority in knowledge question 2;

At the end of the study there are very few significant differences between Biology and non-Biology pupils.

The last three columns depict the possible significant changes in the Biology vs non-Biology differences over the three time intervals. During Interval 1 non-Biology pupils exhibit greater changes on concept question 1, knowledge questions 6 and 8, and attitude statements 8 and 23, but lesser changes on behavioural intention question 28.

Biology pupils improved significantly in relation to non-Biology pupils during interval 2, possibly due to a drop-off effect in non-Biology pupil responses.

The overall long-term effect (Interval 3) indicates that non- Biology pupils have improved significantly on knowledge question 9, attitude statements 8, 15 and 23 of which 15 and 23 are nuclear/coal-related and deteriorated on behavioural intention question 29, in relation to their counterparts. Therefore, it can be said that the non-Biology pupils show greater improvements with regard to nuclear/coal-related issues.

The reasons for the particular outcome of these results could possibly be attributed to Biology pupils' being, on average, more environmentally conscious than non-Biology pupils because of an inherent love of nature and animals which may have led some of them to make this subject choice in the beginning. Only further research can confirm or deny these assumptions.

7.7.1.1 Significant Total Scores for the Various Sections

At the end of the study the Biology group have a higher average behavioral intentions score (A3AG34+) but a lower total knowledge score (K3KG10-), apparently due to the non-Biology group retaining knowledge better (DK2K10-) during the drop-off period (time interval 2).

7.7.2 Differences Associated with Geography

Table 7.7 shows the significant differences associated with the respondents who took Geography, compared with those who did not take Geography.

TABLE 7.7 - SIGNIFICANT VALUES FOR VARIABLE SUB3 - GEOGRAPHY

		Time One CAT	Time One Yes/No	Time Two CAT	Time Two Yes/No	Time Three CAT	Time Three Yes/No	INT 1 D1C	INT 2 D2C	INT 3 D3C
	1									+
C	2									
O	3									
N	4						+			
C	5			-		+				
E	6	+								
P	7									
T	8									
S	9									
K	1									+
N	2									
O	3									
W	4									
L	5									
E	6									
D	7									
G	8	+	+							
E	9									-
	1		+			+	+			
	2						~			
	3	+								
	4									
	5									
	6									
	7									
	8			-						-
A	9	+	+					~		
T	10									
T	11	-								
I	12					-	-		-	
T	13	+	+							
U	14	+	+	+			+			
D	15									
E	16									
S	17									
	18									
	19			+						
	20									
	21									
	22									
	23		+	~		+	+			-
B I										
E N	24						-		-	
H T	25									
A E	26									
V N	27					-	-			
I T	28		-							
O I	29						-			+
U O	30									
R N	31									
A S	32									
L										

Concepts
Knowledge
Attitudes
Beh. Int

A3AG34+

At Time Point 1:-

The Geography pupils scored significantly higher than the non-Geography students on concept question 6, attitude statements 1, 9, 13, 14 and 23, which dealt mainly with elements in the C.E.D. Geography syllabus;

Non-Geography pupils scored significantly higher than Geography pupils in knowledge question 8 and behavioural intention statement 28. The difference meant that before the simulation activity more non-Geography pupils knew when the Three Mile Island nuclear accident happened, and that they were more prepared to give up a Saturday morning to pick up litter than the Geography pupils.

At Time Point 2:-

No significant Geography/non-Geography differences appear.

At Time Point 3:-

The Geography pupils scored significantly higher in the concepts and attitudes sections (i.e. concept question 4, attitude statements 1, 14 and 23), while the non-Geography pupils scored significantly higher in the behavioural intentions section (i.e. statements 24, 27, 28 and 30);

Non-Geography pupils appeared to be more anti-nuclear than the Geography pupils, in terms of their behavioural intentions scores.

Initially, before exposure to the simulation activity, the Geography pupils appear to hold many environmentally sound attitudes, however, in the long-term they seem unwilling to translate these attitudes into action.

The three time intervals collectively seem to indicate that there was very little significant change in the Geography/non-Geography subject differences. Thus, it cannot be claimed that Geography pupils did better or worse than non-Geography pupils as a result of exposure to the simulation activity. Only 5 significant results (at 5 percent level) occurred in some 150 comparisons. The explanation for this particular outcome is not forthcoming.

7.7.2.1 Significant Total Scores for the Various Sections

Geography pupils showed a difference from non-Geograpy pupils only on the total behavioural intentions score (A3AG34+) at the end of the study period, but otherwise no statistical differences existed between these groups for total scores or changes in these scores.

7.7.3 Differences Associated with Mathematics

Table 7.8 shows the significant differences associated with the respondents who took Mathematics, compared with those who did not take Mathematics.

TABLE 7.8 - SIGNIFICANT VALUES FOR VARIABLE SUB5 - MATHS

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1	+	+	+						-
C	2	+	+				+	-	+	
O	3			+	+	+	+			
N	4	+	+	+	+	+	+			
C	5					+	+		-	+
E	6	+	+	+	+		+			
P	7	+								
T	8									
S	9	+	+					-		
K	1		+	+	+	+	+			
N	2		+			+	+		+	
O	3	+	+							
W	4			+	+	+	+			-
L	5									
E	6	+								
D	7								-	
G	8									
E	9							+		-
	1									
	2									
	3					+				
	4									
	5									
	6									
	7			-						
	8									
A	9	+								
T	10									
T	11			-	-					
I	12									
T	13					-			-	
U	14			~						
D	15					+				
E	16									
S	17								+	
	18									-
	19									
	20									
	21									
	22									
	23	+	+	+	+					
B I										
E N	24									
H T	25									
A E	26									
V N	27									
I T	28	-	-		-				-	
O I	29									
U O	30									
R N	31			-						
A S	32									
L										
Concepts			CG10+		C2CG10+	C3CG10+		DC1C10	DC2C10-	DC3C10-
Knowledge						K3KG10+				DK3K10-
Attitudes						A3AG33+			DA2A33-	
Beh. Int									DA2A34-	

At <u>Time Point 1</u>:-

The Mathematics pupils scored significantly higher than the non-Mathematics pupils (before the simulation activity) in the concepts (questions 1, 2, 4, 6 and 9), knowledge (question 1 - 3) and the attitudes sections (statement 23);

The non-Mathematics group scored significantly higher than the Mathematics pupils only in behavioural intentions statements 28.

Table 7.9 Time Point 1 (before the simulation activity)

Item Number		Main Point in Question/Statement
Maths Group		
	CQ1	Ecology
	CQ2	Ecosystem
	CQ4	Spaceship Earth
	CQ6	Environment
	CQ9	Radioactive half-life
	KQ1	Radiation
	KQ2	Plutonium
	KQ3	Acid Rain
	AS23	Alternative energy sources
Non-maths Group		
	BIS28	Litter pickup

On closer examination of these items (Table 7.9) the only pattern that emerges is that the Mathematics pupils appeared to have had a greater understanding of environmental concepts, knowledge and attitudes than the non-Mathametics pupils before the simulation activity.

At Time Point 2:-

The Mathematics pupils have maintained their superiority in the concepts, knowledge and attitudes sections, although the number of items has dropped and varied (i.e. concept questions 3,4 and 6, knowledge questions 1 and 4 and attitude statement 23);

While the non-mathematics pupils maintained their superiority in behavioural intention statement 28, they also scored significantly higher than the Mathematics pupils in attitude statement 11.

Table 7.10 Time Point 2 (after the simulation activity)

Item Number	Main Point in Question/Statement
Maths Group	
CQ3	Nature conservation
CQ4	Spaceship Earth
CQ6	Environment
KQ1	Radiation
KQ4	Nuclear fission
AS23	Alternative energy sources
Non-maths Group	
AS11	Electricity/nuclear power
BIS28	Litter pickup

The superiority displayed by the Mathematics pupils at time point 1 shows slight abatement after exposure to the simulation activity (Table 7.10). The non-Mathematics pupils now show an improvement in attitude statement 11 which deals with electricity/nuclear power - the topic of the simulation activity.

At Time Point 3:-

The Mathematics pupils continue to score significantly higher than the non-Mathematics pupils in the concepts and knowledge sections (i.e. concept questions 2, 3, 5, 6 and knowledge questions 1, 2 and 4);

No significant differences occurred in the attitudes and behavioural intentions sections.

The Mathematics pupils were consistently superior to the non-Mathematics pupils (in terms of higher scores) in the concepts and knowledge sections (Table 7.11).

Table 7.11 Time Point 3 (5 - 10 weeks after the simulation activity)

Item Number	Main Point in Question/Statement
Maths Group	
CQ2	Ecosystem
CQ3	Nature conservation
CQ5	Greenhouse effect
CQ6	Environment
KQ1	Radiation
KQ2	Plutonium
KQ4	Nuclear fission
Non-maths Group	
--	--

The last three columns indicate significant changes which might have occurred in these subject differences over the 3 time intervals. During Interval 1 the non-Mathematics group shows a significant relative improvement in the concepts section (i.e. question 2 and 9), while the Mathematics pupils show a relative improvement in the knowledge section (i.e. question 9). Table 7.12 indicates no significant item pattern or exploration for the particular result.

Table 7.12 Interval 1

Item Number	Main Point in Question/Statement
Maths Group	
KQ9	Rachel Carson
Non-maths Group	
CQ2	Ecosystem
CQ9	Radioactive half-life

During Interval 2 there were more instances of significant change in the Mathematics subject differences than there were in Interval 1. In the concepts, knowledge and attitudes sections changes in the differences favour both the Mathematics pupils (concept question 2, knowledge question 2 and attitude statement 19) and the non-Mathematics pupils (concept question 5, knowledge question 7 and attitude statement 14). There is no clear superiority in improvement for either group (Table 7.13).

Table 7.13 Interval 2

Item Number	Main Point in Question/Statement
Maths Group	
CQ2	Ecosystem
KQ2	Plutonium
AS19	Pollution
Non-maths Group	
CQ5	Greenhouse effect
KQ7	Background radiation
AS14	Recycling

During Interval 3 in the concepts section both the Mathematics and non-Mathematics pupils have again showed a single significant relative improvement (i.e. Mathematics pupils in question 5 and non-Mathematics pupils in question 1). The non-Mathematics pupils have displayed relative improvements in the knowledge (i.e. question 4 and 9) and attitude sections (i.e. statement 21) in Table 7.14.

Table 7.14 Interval 3

Item Number	Main Point in Question/Statement
Maths Group	
CQ5	Greenhouse effect
Non-maths Group	
CQ1	Ecology
KQ4	Nuclear fission
KQ9	Rachel Carson
AS21	Littering

In the long-term the non-Mathematics pupils seem to improve relative to their Mathematics counterparts.

It is difficult in this study to draw definite conclusions as to why Mathematics or non-Mathematics pupils made their specific responses or choices other than to acknowledge that different choices were made.

7.7.3.1 Significant Total Scores for the Various Sections

Mathematics pupils exhibit superior conceptual scores (CG10+, C2CG10+ and C3CG10+) at all time points, but non-Mathematics pupils exhibit stronger short-term and long-term gains (DC1C10- and DC3C10-) and greater drop-off period effects (DC2C10-). Mathematics pupils had a higher final knowledge score (K3KG10+) due to drop-offs in the non-Mathematics group (DK3K10-). Final Mathematics attitude scores are lower (A3AG33+) due to a larger drop-off in scores (DA2A33+). This larger drop-off which contributed to a substantially greater change in behavioural intentions (DA2A34-) in the non-Mathematics group.

7.7.4 Differences Associated with Physical Science

Table 7.15 shows the significant differences associated with the respondents who took Physical Science, compared with those who did not take Physical Science.

TABLE 7.15 - SIGNIFICANT VALUES FOR VARIABLE SUB6 - SCIENCE

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1			+						
C	2									
O	3									
N	4	+		+	+				-	
C	5			+	+			+		
E	6									
P	7									
T	8									
S	9	+	+	+	+	+	+	-	-	-
K	1	+	+	+	+	+	+		-	
N	2	+	+	+	+	+	+	-		
O	3		+							
W	4	+	+	+	+	+	+	-		
L	5									
E	6			+		+				
D	7			+	+			+		
G	8							+		
E	9							+		+
	1	+	-	-		-		+		+
	2									
	3									
	4	-	-			-	-	+	-	-
	5			-	-					
	6									
	7									
	8									
A	9			+	+			+		
T	10									
T	11					-		-		
I	12		+							
T	13									
U	14									
D	15	-	-	-	-	-				
E	16					+				
S	17									-
	18		-							
	19	+	+	+	+					-
	20									
	21					-				-
	22									
	23									
B I										
E N	24									
H T	25									
A E	26									
V N	27									
I T	28		-	-	-					
O I	29					-	-			
U O	30	-	-	-		-				
R N	31									
A S	32									
L										

Concepts	CG10+	C2CG10+	C3CG10+	DC2C10-
Knowledge	KG10+	K2KG10+	K3KG10+	
Attitudes			A3AG33+	DA2A33+DA3A33-
Beh. Int			A3AG34+	

At <u>Time Point 1</u> :-

Physical Science pupils have scored significantly higher in the concepts and knowledge sections (i.e. concept question 9 and knowledge questions 1-4) than non-Physical Science pupils;

Non-Physical Science pupils have scored significantly higher in the attitudes and behavioural intentions sections (i.e. attitude statements 1, 4, 15 and 18 and behavioural intentions statements 28 and 30) (Table 7.16). These differences, upon closer scrutiny are of interest, because they show a strong anti-nuclear pattern by non-Physical Science pupils in the attitudes section (i.e. statements 1, 4 and 15).

Table 7.16 Time Point 1 (before the simulation activity)

Item Number	Main Point in Question/Statement
<u>Physical Science Group</u>	
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium
KQ3	Acid Rain
KQ4	Nuclear Fission
AS23	Alternative energy sources
<u>Non-Physical Science Group</u>	
AS1	Nuclear power
AS4	Nuclear power
AS15	Nuclear wastes
AS18	Science and technology
BIS28	Litter pickup
BIS30	Discourage nuclear power station

At Time Point 2:-

Physical Science pupils have scored significantly higher in the concepts and knowledge sections (i.e. concept questions 4, 5 and 9, and knowledge questions 1, 2, 4 and 7) than non-Physical Science pupils; Non-Physical Science pupils scored significantly higher than Physical Science pupils on attitude statements 5 and 15, the opposite was true for attitude statements 9 and 19 (Table 7.17). Closer examination of these scores suggests that non-Physical Science pupils, in terms of attitudes are more anti-nuclear than Physical Science pupils. The reasons for these results did not become entirely clear during the study nor on examination of the results themselves, other than those involved in the humanities appear to be anti-nuclear as opposed to those in the sciences.

Table 7.17 Time Point 2 (directly after the simulation activity)

Item Number	Main Point in Question/Statement
Physical Science Group	
CQ4	Spaceship Earth
CQ5	Greenhouse effect
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium
KQ4	Nuclear fission
KQ7	Natural background radiation
AS9	Population explosion
AS19	Pollution
Non-Physical Science Group	
AS5	Use of coal
AS15	Nuclear wastes

At Time Point 3:-

Previous differences are no longer so apparent, however, Physical Science pupils continue their superiority in the concepts (question 9) and knowledge sections (i.e. questions 1, 2 and 4); while non-Physical Science pupils retain their superiority in attitude statement 4 and behavioural intentions statement 29 (Table 7.18).

Table 7.18 Time Point 3 (5 - 10 weeks after the simulation activity)

Item Number	Main Point in Question/Statement
Physical Science Group	
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium
KQ4	Nuclear fission
Non-Physical Science Group	
AS4	Nuclear power
BIS29	Money for conservation

Physical Science pupils appear to have done better in the concepts and knowledge sections at each of the time points while non-Physical Science pupils did better in the attitudes and behavioural intentions sections. It should be noted that this superiority is based upon global patterns which have emerged in the results and not individual items. It therefore becomes difficult to explain why specific item choices were made. Only assumptions as to why these choices were made can be offered.

During Interval 1 a number of changes occur, most of these being improvements for Physical Science pupils (i.e. concept question 5, knowledge questions 7-9 and attitude statements 1, 4 and 9). Non-Physical Science pupils displayed relative improvement in concept question 9, knowledge questions 2, 4 and attitude statement 12, possibly due to exposure to the simulation activity (Table 7.19).

Table 7.19 Interval 1

Item Number	Main Point in Question/Statement
Physical Science Group	
CQ5	Greenhouse effect
KQ7	Natural background radiation
KQ8	Three Mile Island
KQ9	Rachel Carson
AS1	Nuclear power
AS4	Nuclear power
AS9	Population explosion
Non-Physical Science Group	
CQ9	Radioactive half-life
KQ2	Plutonium
KQ4	Nuclear fission
AS12	Population explosion

During Interval 2 only non-Physical Science pupils show relative improvements (i.e. concept questions 4 and 9, knowledge question 1 and attitude statement 4) (Table 7.20).

Table 7.20 Interval 2

Item Number	Main Point in Question/Statement
Physical Science Group	
--	--
Non-Physical Science Group	
CQ4	Spaceship Earth
CQ9	Radioactive half-life
KQ1	Radiation
AS4	Nuclear power

During Interval 3 non-Physical Science pupils improve (relatively) in two items (knowledge question 9 and attitude statement 1) (Table 7.21).

Table 7.21 Interval 3

Item Number	Main Point in Question/Statement
Physical Science Group	
--	--
Non-Physical Science Group	
KQ9	Radioactive half-life
AS1	Nuclear power

No relative improvements occurred in the behavioural intentions sections. Most of the significant changes occurred during interval 1 with fewer in intervals 2 and 3. The overall implication of this is that most of the changes occurred after the simulation activity had been experienced while a distinct drop-off period was noticed in intervals 2 and 3.

7.7.4.1 Significant Total Scores for the Various Sections

The Science group versus the non-Science group comparisons showed similar tendencies to the Maths/Non-Maths comparisons, but in addition the Science group was superior in knowledge at all time points (KG10, K2KG10, K3KG10). The non-Science group had superior final behavioural intentions scores (A3AG34).

7.7.5 Differences Associated with Mathematics and Physical Science

Table 7.22 shows the significant relative improvements associated with the respondents who took Mathematics and Physical Science, compared with those who did not take both subjects.

TABLE 7.22 - SIGNIFICANT VALUES FOR VARIABLE SUB7 - MATHS/SCI VS REST

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1			+	+					
C	2									
O	3									
N	4	+		+	+				-	
C	5			+	+	+		+		
E	6				+					
P	7									
T	8									
S	9	+	+	+	+	+	+	-	-	-
K	1	+	+	+	+	+	+		-	
N	2	+	+	+	+	+	+	-		
O	3		+							
W	4	+	+	+	+	+	+	-		
L	5									
E	6			+		+				
D	7			+	+			+		
G	8									
E	9							+		+
	1	-	-			+		+		+
	2									
	3					+	-		-	-
	4	-	-		-					
	5									
	6									
	7									
	8									
A	9			+	+			+		
T	10									
T	11					-				
I	12		+					-		
T	13									
U	14									
D	15	-	-							
E	16									
S	17									
	18									
	19	+	+	+	+					-
	20									
	21					-				-
	22									
	23									
B I										
E N	24									
H T	25									
A E	26									
V N	27									
I T	28		-	-	-					
O I	29						-			
U O	30	-	-	-		-				
R N	31									
A S	32									
L										

	Time One	Time Two	Time Three	INT
Concepts	CG10+	C2CG10+	C3CG10+	DC2C10+
Knowledge	KG10+	K2KG10+	K3KG10+	DK2K10+DK3K10+
Attitudes			A3AG33-	DA2A33-DA3A33-
Beh. Int			A3AG34-	DA3A34-

At <u>Time Point 1</u> :-

Before the simulation activity the Maths/Science pupils scored significantly higher than the non-Maths/Science pupils in the knowledge section (i.e. in questions 1 - 4);

The Maths/Science pupils also scored significantly higher than the non-Maths/Science pupils on statement 12 and 19 of the attitudes section and in question 9 of the concepts section;

The non-Maths/Science pupils on the other hand scored significantly higher than the Maths/Science group on question 9 in the knowledge section, on statements 1,4 and 15 in the attitudes section, and on statements 28 and 30 in the behavioural intentions section (Table 7.23).

Table 7.23 Time Point 1 (before the simulation activity)

Item Number	Main Point in Question/Statement
Maths/Science Group	
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium
KQ3	Acid Rain
KQ4	Nuclear fission
AS12	Population explosion
AS19	Pollution
Non-maths/Science Group	
KQ9	Rachel Carson
AS1	Nuclear power
AS4	Nuclear power
AS15	Nuclear wastes
BIS28	Litter pickup
BIS30	Discourage nuclear power building

On closer examination the non-Maths/Science attitudes and behavioural intentions sections indicate a predominantly anti-nuclear viewpoint.

At Time Point 2:-

After exposure to the simulation activity the Maths/Science pupils show a distinct superiority in the concepts and knowledge sections (i.e. concepts questions 1, 4, 5, 6 and 9 and knowledge questions 1, 2, 4 and 7);

In the attitudes section the non-Maths/Science pupils' items (statements 5 and 15) are once again anti-nuclear in content, the Maths/Science pupils appear superior on statements 9 and 19.

The non-Maths/Science pupils again scored significantly higher on statement 28 in the behavioural intentions section.

The Maths/Science pupils scored significantly higher than the non-Maths/Science pupils in both the concepts and knowledge sections. While the non-Maths/Science pupils appear (in terms of reflecting an anti-nuclear stance) to be superior in the attitudes and behavioural intentions sections (Table 7.24).

Table 7.24 Time Point 2 (directly after the simulation activity)

Item Number	Main Point in Question/Statement
Maths/Science Group	
CQ1	Ecology
CQ4	Spaceship Earth
CQ5	Greenhouse effect
CQ6	Environment
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium

KQ4	Nuclear fission
KQ7	Natural background radiation
AS9	Population explosion
AS19	Pollution
Non-maths/science Group	
AS5	Coal
AS15	Nuclear wastes
BIS28	Litter pickup

At Time Point 3:-

The Maths/Science pupils have maintained their superiority in the knowledge section (i.e. in questions 1,2 and 4) and in concept question 9;

The non-Maths/Science pupils have scored significantly higher in attitudes statement 4 and behavioural intentions statement 29 (Table 7.25).

Table 7.25 Time Point 3 (5 - 10 weeks after the simulation activity)

Item Number	Main Point in Question/Statement
Maths Group	
CQ9	Radioactive half-life
KQ1	Radiation
KQ2	Plutonium
KQ4	Nuclear fission
Non-maths Group	
AS4	Nuclear power
BIS29	Money for conservation

At this time point there are fewer items associated with these subject differences, however they are still significant. Firstly, the Maths/Science pupils still dominate the concept and knowledge sections while the non-Maths/Science pupils dominate the attitudes and behavioural intentions sections. Secondly, almost all the items in question deal with nuclear/coal related issues.

During <u>Time Interval 1</u> the Maths/Science pupils showed relative improvements in the following items: concept question 5, knowledge questions 7 and 9, and attitude statements 1 and 9. The non-Maths/Science pupils showed relative improvements in concept question 9, knowledge questions 2 and 4, and attitude statement 12. No relative improvements were recorded in the behavioural intentions section (Table 7.26).

Table 7.26 Interval 1

Item Number	Main Point in Question/Statement
<u>Maths/Science Group</u>	
CQ5	Greenhouse effect
KQ7	Natural background radiation
KQ9	Rachel Carson
AS1	Nuclear power
AS9	Population explosion
<u>Non-maths/Science Group</u>	
CQ9	Radioactive half-life
KQ2	Plutonium
KQ4	Nuclear fission
AS12	Population explosion

During <u>Time Interval 2</u> a dramatic drop-off effect has taken place. The non-Maths/Science pupils showed significant relative improvements in concept questions 4 and 9, knowledge question 1, and attitude statement 4. Once again no relative changes occurred in the behavioural intentions section (Table 7.27).

Table 7.27 Interval 2

Item Number	Main Point in Question/Statement
Maths/Science Group	
--	--
Non-Maths/Science Group	
CQ4	Spaceship Earth
CQ9	Radioactive half-life
KQ1	Radiation
AS4	Nuclear power

During Time Interval 3 the Maths/Science pupils show an overall relative improvement in knowledge question 9 and attitude statement 1. The non-Maths/Science pupils show relative improvements in concept question 9 and attitude statement 4, 19 and 21 (Table 7.28).

Table 7.28 Interval 3

Item Number	Main Point in Question/Statement
Maths/Science Group	
KQ9	Rachel Carson
AS1	Nuclear power
Non-Maths/Science Group	
CQ9	Radioactive half-life
AS4	Nuclear power
AS19	Pollution
AS21	Littering

7.7.5.1 Significant Total Scores for the Various Sections

The Mathematics/Physical Science group exhibits the same tendencies as that of the individual Science and the Maths groups. They are superior in concept and knowledge (CG10+, C2CG10+, C3CG10+, KG10+, K2KG10+, K3KG10+) to their counterparts at all time points studied and experience lower drop-off effects (DC2C10, DK2K10, DK3K10). But in the final attitudes and behavioural intentions scores they score lower (A3AG33-, A3AG34-) due to significantly stronger drop-offs in these spheres. The overall change in attitudes is substantially worse than that of their counterparts, possibly due to increasing support for nuclear power in this subgroup (DA3A33-).

7.7.6 Differences Associated with Biology and Geography

Table 7.29 shows the significant differences associated with the respondents who took Biology and Geography (Bio/Geog), compared with those who did not take both these subjects.

TABLE 7.29 - SIGNIFICANT VALUES FOR VARIABLE SUB8 - BIO/GEOG VS REST

		Time One		Time Two		Time Three		INT 1	INT 2	INT 3
		CAT	Yes/No	CAT	Yes/No	CAT	Yes/No	D1C	D2C	D3C
	1						+			
C	2		+	+	+					-
O	3									
N	4									
C	5				-					
E	6									
P	7			+	+					
T	8									
S	9									
K	1								+	
N	2						-			
O	3			-						
W	4									
L	5									
E	6									
D	7									
G	8									
E	9	+	+		+					
	1					+				
	2									
	3	+	+					-		-
	4						+		+	+
	5									
	6									
	7									
	8									
A	9			-	-			-		
T	10									
T	11									
I	12						-		-	
T	13									
U	14									
D	15	+	+			+				
E	16					-	-		+	
S	17									
	18				-					
	19			-						
	20	+								
	21									
	22									
	23	+	+	+	+				+	+
B I										
E N	24	-								
H T	25									
A E	26									
V N	27									
I T	28									
O I	29									
U O	30									
R N	31									
A S	32									
L										

Concepts
Knowledge DK2K10-
Attitudes A3AG33+
Beh. Int DA3A34-

At Time Point 1:-

Bio/Geog pupils scored significantly higher than non-Bio/Geog pupils in concept question 2, knowledge question 9, and attitude statements 3,15 and 23. Non-Bio/Geog pupils did not score significantly higher than Bio/Geog pupils on any of the items in any of the sections.

No significant differences were recorded in the behavioural intentions section (Table 7.30).

Table 7.30 Time Point 1 (before the simulation activity)

Item Number	Main Point in Question/Statement
Bio/Geog Group	
CQ2	Ecosystem
KQ9	Rachel Carson
AS3	Coal-fired power stations
AS15	Nuclear wastes
AS23	Alternative energy sources
Non-Bio/Geog Group	
--	--

Bio/Geog pupils were at a slight advantage in terms of being familiar with some issues addressed in the questionnaire items, as might have been expected because most of these concepts are covered in both respective syllabi.

At Time Point 2:-

Bio/Geog pupils scored significantly higher than non-Bio/Geog pupils in concept questions 2 and 7, knowledge question 9 and attitude statement 23.

Non-Bio/Geog pupils scored significantly higher than Bio/Geog pupils in concept question 5 and attitude statements 9 and 18.

There were no significant differences recorded in the behavioural intentions section (Table 7.31).

Table 7.31 Time Point 2 (directly after the simulation activity)

Item Number	Main Point in Question/Statement
Bio/Geog Group	
CQ2	Ecosystem
CQ7	Food chain
KQ9	Rachel Carson
AS23	Alternative energy sources
Non-Bio/Geog Group	
CQ5	Greenhouse effect
AS9	Population explosion
AS18	Science and technology

At Time Point 3:-

Bio/Geog pupils scored significantly higher than non-Bio/Geog pupils in only two items (concept question 1 and attitude statement 4).

Non-Bio/Geog pupils scored significantly higher than Bio/Geog pupils in three items (i.e. knowledge question 2, and attitude statements 12 and 16).

Yet again, no significant differences appear in the behavioural intentions section (Table 7.32).

Table 7.32 Time Point 3 (5 - 10 weeks after the simulation activity)

Item Number	Main Point in Question/Statement
Bio/Geog Group	
CQ1	Ecology
AS4	Nuclear power
Non-Bio/Geog Group	

KQ2	Plutonium
AS12	Population explosion
AS16	Whales

During Interval 1 there are very few relative improvements (three in all) and they are attributable to non-Bio/Geog pupils (i.e. concept question 5 and attitude statements 3 and 9). No relative improvements occur in the behavioural intentions section (Table 7.33).

Table 7.33 Interval 1

Item Number	Main Point in Question/Statement
Bio/Geog Group	
--	--
Non-Bio/Geog Group	
CQ5	Greenhouse effect
AS3	Coal-fired power stations
AS9	Population explosion

During Interval 2 there were no significant changes recorded in the concepts section. Only Bio-Geog pupils show relative improvements, in knowledge question 2 and attitude statements 4, 16 and 22. There were again no relative improvements recorded in the behavioural intentions section (Table 7.34).

Table 7.34 Interval 2

Item Number	Main Point in Question/Statement
Bio/Geog Group	
KQ2	Plutonium
AS4	Nuclear power
AS16	Whales
AS22	Environmental/political problems
Non-Bio/Geog Group	
--	--

During Interval 3 there are four relative changes recorded (two improvements for each grouping). Non-Bio/Geog pupils showed significant change in concept question 2 and attitude statement 3, while Bio/Geog pupils showed significant changes in attitude statements 4 and 22. Relative improvements are absent in the behavioural intentions section (Table 7.35).

Table 7.35 Interval 3

Item Number	Main Point in Question/Statement
Bio/Geog Group	
AS4	Nuclear power
AS22	Environmental/political problems
Non-Bio/Geog Group	
CQ2	Ecosystem
AS3	Coal-fired power stations

7.7.6.1 Significant Total Scores for the Various Sections

The subset taking Biology and Geography differed from the remaining pupils in total attitude scores at the end of the study period (A3AG33+). However, they showed substantially greater losses in knowledge during the drop-off period (DK2K10-). The overall change in behavioural intentions (DA3A34-) was greater for non-Biology/Geography than the Biology/Geography subgroup.

7.8 CONCLUDING REMARKS

The simulation activity did attain a measure of success in conveying knowledge, concepts and affecting pupils' attitudes and behavioural intentions.

Females tended to perform better than males in terms of producing the attitudes and behavioural intentions that were in the researcher's view desirable.

The differences associated with the subject groupings were generally not as definitive as those associated with the gender differences possibly because of the small sample and subsamples used and because of contrasting sample sizes of those taking and not taking a particular subject or set of subjects (e.g. those taking Mathematics, 172 pupils, while only 34 pupils did not take Mathematics). In addition, for any given subject comparison, there are in the background the confounding effects of other subjects taken or not taken by pupils.

A number of interesting factors did emerge, however; for example that the Mathematics pupils displayed a superiority over non- Mathematics pupils in the area of concepts and knowledge. This phenomenon was also evident between the Physical Science pupils and the non-Physical Science pupils, as these divisions yielded roughly the same set of students. On the other hand, the non- Mathematics pupils displayed a general superiority in the attitudes and behavioural intentions sections (as did non-Physical Science pupils). One could possibly generalize here and summarize that pupils in the sciences appear to be more comfortable with numbers, concepts and information while pupils in the humanities tend to be able to empathize more easily.

Although the researcher notes changes in pupil conceptual ability and in attitude after participating in the simulation activity, it was frequently difficult to explain these (eg p.121, 123, 134, 135, 138, 144, 147 and 148). It was considered to be beyond the scope of this thesis to investigate reasons for contrasting changes in different pupil groups. Explanations for score changes might have been found by including a Semantic Differential assessment of pupil interest, boredom, confidence, confusion, enjoyment, comprehension and appreciation of the simulation activity.

For the researcher, the analysis of the results of the Coal or Nuclear simulation activity exhibit a favourable outcome, in that pupils had the opportunity to re-examine their own and alternative environmental concepts, knowledge, attitudes and behavioural intentions. The results also confirm that a number of pupils gained new environmental concepts and knowledge while changing (or altering) some environmental attitudes and behavioural intentions in the short-term.

As expected, there was a drop-off effect with time, illustrating the need for supportive material to be used in conjunction with such a simulation activity. If appropriate changes are to be presumed and become part of the (repertoire of) experience of these pupils, it is hoped that they will carry these into future life experiences.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1 COMMENTS ON THE SIMULATION ACTIVITY

The simulation activity formulated as a teaching method for EE was found to be effective. The effectiveness of the 'Coal or Nuclear' simulation activity needs however to be qualified. The simulation activity although fulfilling its aim of being able to deal with the tripartite nature of EE by:

(a) increasing pupils' environmental knowledge;

(b) affecting pupils' environmental attitudes; and

(c) inducing some of the pupils to take action on behalf of the protection of the environment, did not satisfactorily create an awareness amongst pupils of the human-environmental crisis, but was dominated by the nuclear/coal debate. Future research into EE and the effective use of simulation activities and EE might deal with many aspects of the human-environmental crisis, in addition to the particular issue of this project.

The researcher's focus was mainly on the nuclear/coal issue in the context of an environmental theme, rather than EE in its entirety.

The length of time required for the simulation activity (i.e. 80 minutes) might be a problem at schools where the duration of classes is less than 40 minutes. However, with the necessary interest and cooperation among principals and staff members, time shortages could be sorted out.

The base map could be adjusted so as to be more realistic and applicable to the different areas and regions of South Africa. Thus, the simulation activity's framework could remain the same, while the content could be changed to suit the particular person, school or organization.

The sample population was not the most desirable: a more representative South African sample could be addressed in future research.

8.2 COMMENTS ON THE THREE QUESTIONNAIRES

The set of three questionnaires devised to assess the effectiveness of the simulation activity proved to be efficient.

The results of the preliminary questionnaire depicted the position of the pupils before the simulation activity with regard to their environmental knowledge, concepts, attitudes and behavioural intentions. The results of the second questionnaire demonstrated the changes which occurred as a result of exposure to the simulation activity.

The final questionnaire's results displayed a drop-off effect in terms of the changes which had occurred after taking part in the simulation activity.

The length of each questionnaire appeared to be ideally suited in respect of time and the multi-disciplinary nature of EE.

Despite the apparent success of the questionnaires (in this research project) there are shortcomings associated with this method. Thus, further research on this topic could possibly examine the use of a complementary method to that of questionnaires, for example, interviewing.

8.3 IMPLICATIONS AND INFERENCES

The value of simulation activities as a teaching technique for EE is highlighted by the apparent lack of such techniques. This study also substantiates the view that:

> "it is already clear that these techniques have proved useful to a number of teachers and that they might have an even wider role in improving learning opportunities throughout the world" (Taylor, 1987, p. 10).

However, this study also makes it quite clear that in any proposed EE programme supportive material is necessary, if not vital, for long-term learning to be maintained.

The overall limitation of this study i.e. that it deals only with White, Cape Education Department English-speaking secondary school pupils, should not detract from the conclusion that the simulation activity succeeded.

It seems reasonable to extrapolate and claim that the simulation technique may prove just as effective in all South African schools (with the appropriate regional, cultural and language adjustments being made).

The limitations of this study are far outweighed by the fact that this research breaks new ground, in that it is one of the few (if not the only) quantitative study evaluating simulation activities as a secondary school teaching technique for environmental education.

If this research is carried out in a single education system for all in South Africa, it is hoped that the same results as those of this study will emerge. Therefore further research is necessary whereby a similar research project could be carried out in Black, 'Coloured' and Indian schools and the results compared. A similar project could also be done comparing state and independent schools. However, the important point to emerge here is that in the present climate of hope, change and the inevitability of open schools more research in this field is extremely necessary if not vital. As South Africa moves towards an open, post-apartheid society, the fundamental political consequences of environmental attitudes throughout the community will be of much more than academic interest.

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APPENDIX 1

BRIEFING PROCEDURE FOR PARTICIPANTS

(±15 minutes)

1. Briefly describe what is meant by the 'human-environmental crisis' and how the 'Coal or Nuclear' simulation activity fits into it. Read "Setting the Scene" to participants. Show participants base-map.

2. Ask participants who would like to play the role of nature conservationists (choose participants with strong personalities - gauged from previous discussions with teachers). Choose two nature conservationists. They will form group 6 (corresponding to area 6 on the base-map).

3. Then divide the class up into a further five groups (as discussed with teachers). This will ensure at least two strong, dominant personalities to be present in each of the five groups. The size of each group will be dependent upon the total class number. The desired total number of participants is 32. This will in effect produce six groups with five members each, and one group with two members (nature conservationists).

4. There will now be seven separate groups numbered 1 to 7.

5. Groups 1 to 5 will be made up of town councillors each representing a particular ward (eg. Group 1 will represent Ward 1 on the base map).

6. The participants in groups 1 to 5 will now be asked to choose individual roles based on their particular wards.

7. Each group (except group 6) should now elect two members,

one who will go forward to represent that group on the Council's Management Committee (Group 7), while the other person will be the chairperson of the group.

8. The Management Committee group should now elect a chairperson (who will have a final overall casting vote in any voting situation), who automatically becomes mayor/mayoress.

9. The chairperson in each of the other groups will have a casting vote only with regard to voting in their own groups.

10. It is crucial to note (and point out) that the participants must remain "themselves", i.e. retain their own particular feelings, emotions, attitudes, etc. while "playing" their particular roles.

APPENDIX 2

SETTING THE SCENE: NOTES FOR PARTICIPANTS

Base map of Simonsville, a town somewhere along the SW coast of Eternia, a democratic southern African country.

Climate

Simonsville has a mediterranean climate, with most of the rain falling in winter, and a summer drought. North-westerly winds predominate in winter, with south-easterlies blowing during summer.

Population

Approximately 100 000 people.

Remember: Population growth rate at approximately 3% per annum. More people mean greater demands for (just some of) the following :

- food
- energy
- space
- recreation
- housing
- waste disposal
- medical facilities
- jobs
- water

Energy

Simonsville gets all of its energy requirements from a coal-fired power station. Coal for the power station is brought in via road from Zula (a province 1000 km to the north) at great cost because of the distance. A recent geological survey of the Simonsville area has indicated that there are vast quantities of low grade coal in area 6 - the Nature Reserve (it has not been exploited at present because (a) it is still cheaper at the moment to import coal than it would be to exploit it, and (b) the coal reserves are located in a nature reserve). Eternia as a country has ample coal reserves for approximately 300 years. Alternative energy sources such as solar, wind, waves and tidal if they are going to be used, will take a number of years to research and test before they can come into national operation. Thus for the immediate future the only options are coal or nuclear.

Pollution from coal-fired power station in the form of ash fallout and acid rain (the combination of sulphur dioxide, nitrogen oxides and water in the atmosphere) is beginning to cause concern within the town, especially amongst the residents/workers in Wards 2 and 3.

Other Resources

Food is supplied from the agricultural areas in Wards 1 and 4.

Water for domestic and industrial uses is obtained from the river.

There is a local fishing industry.

All land which is outside of the designated Areas 1 - 6 is municipal land. At present the land is unexploited but has been earmarked for possible development as the town expands. Although this land is covered with indigenous "fynbos" vegetation which is found only in the SW part of Eternia, it will not be threatened because the Town Council has set up a large Nature Reserve comprising the whole of area 6.

Wards

Simonsville is divided up into 6 wards (the wards correspond with the numbers on the base map).

Ward 1

* Major agricultural area.

* Supplies town with fruit, vegetables and dairy products.

* Contains some of the areas of indigenous vegetation (including indigenous fauna).

Ward 2

* Simonsville's coal-fired coal power station is situated here.

* This ward also contains a large residential suburb and a commercial zone.

* Contains some area of indigenous vegetation (including indigenous fauna).

Ward 3

* This is the CBD (Central Business District) with an adjoining residential suburb.

* All indigenous vegetation and fauna removed from this area by development.

Ward 4

* This area is a combination of commercial zones, agricultural land and some areas of indigenous vegetation and fauna.

* The town's sewage works is also situated here.

Ward 5

* This area is made up of the following: a commercial zone, a residential suburb, an industrial area, a fishing harbour and the town's rubbish dump.

* An endangered species (a species threatened with possible extinction) of vulture nests in the mountains of this area. Most of the indigenous vegetation and fauna has become extinct.The vulture colony is also threatened.

Area 6

* This area is a proclaimed nature reserve set aside for the protection and management of indigenous vegetation and fauna. Nature conservationists should be committed to a policy of conservation (whereby all the natural resources including plants and animals should be wisely managed so that we do not "run out" of them). This is akin to the "Spaceship Earth" concept put forward by R. Thomas-Tanner which states as follows:

> "Our little Spaceship Earth whirls on through the fleeting stars of night. Except for sunlight, her fuel and supplies are all on board. There's no going back for more, and there's no getting off to some better place. Spaceship Earth is off the pad, and we're the crew, the only crew she's got.

It has only resident nature conservationists and researchers in it; they have <u>no voting</u> rights in the municipal council, although they can express their feelings and opinions regarding Simonsville matters.

<u>Some General Point to Consider</u>

When the proposals are debated the following are some of the points that should possibly be taken into consideration.

* The building of roads, bridges, drainage systems.
* The supply of electricity.
* Increased housing, sewage disposal, water demands, rubbish disposal demands.
* Job opportunities.
* Recreation areas.
* New developments, industrial and commercial areas.
* Medical, social and educational facilities.
* Who will benefit from the proposals, in the short and long term?
* What will the ultimate cost be - social, economic and political?
* What will the impact be of such a proposal on the environment (<u>meaning the natural and human-made</u>

environment)?

* Will disruption of the ecology (interrelationships between living organisms including people and their surroundings) of an area matter?

* What will the impact of the proposals have on specific ecosystems (a system involving the interactions between a community of biotic (living) organisms and their physical surroundings) such as the wetlands, dune fields and estuary?

* Pollution of various kinds could cause (a) the accumulation of toxic (poisonous) substances in the food-chains (the transfer of energy through a series of living organisms) of plants and animals which would ultimately affect humans: (b) it could also destroy habitats (natural place of abode or domicile) of plants, animals and people; and (c) directly harm or kill plants, animals and humans.

* Is development more important than conservation?

* Don't conservationists/environmentalists merely obstruct necessary economic growth?

* Will saving an endangered species of plant or animal save people's lives or provide jobs?

* How do these issues affect me as an architect, lawyer, unemployed worker, student, etc.?

Nuclear Power

- Does the nuclear issue involve only power stations? What about the entire nuclear fuel cycle?

- Is it essential to use nuclear power only for peaceful purposes, eg. producing electricity?

- Maybe we desperately need it for defense purposes?

- What are the long term implications of nuclear power?

Coal

- It is cheap, but it is dirty - pollutes environment (especially air) - so nuclear power is preferable?

- Coal has many other uses, eg. nylon, synthetic fuels (petrol from coal).

* You must weigh up the consequences of both of these developments in the light of all of the above points of consideration (and any others not mentioned).

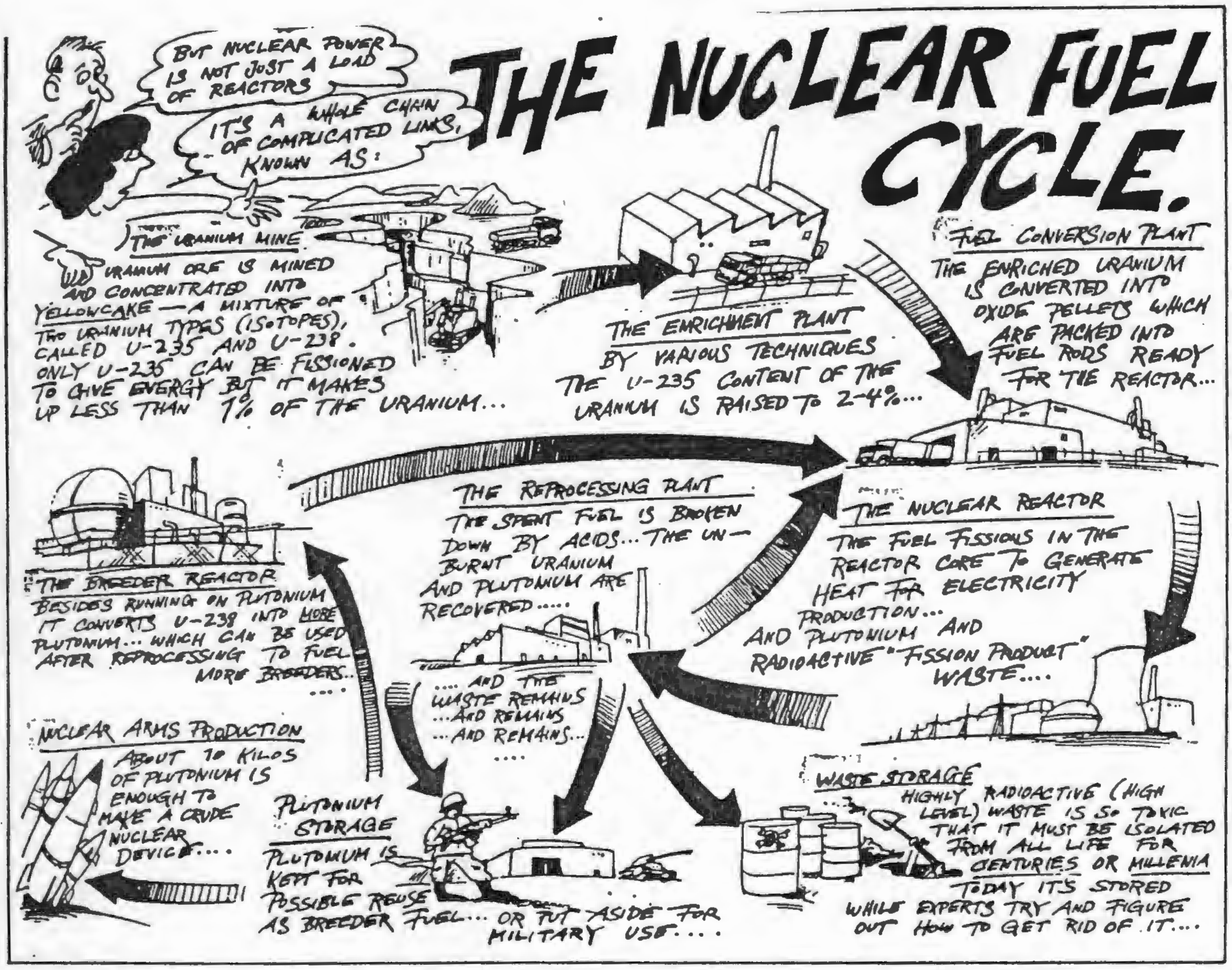
* What about long-term energy needs?

* Maybe urgent, in-depth research should be conducted into the use of alternative energy resources (which are 'clean and safe') such as solar, wind, wave and tidal options?

* These could then gradually replace nuclear or coal, being used only as short-term solutions for a country's energy requirements.

APPENDIX 3

INFORMATION SHEETS FOR SIMULATION ACTIVITY PARTICIPANTS



Outline of the nuclear fuel cycle

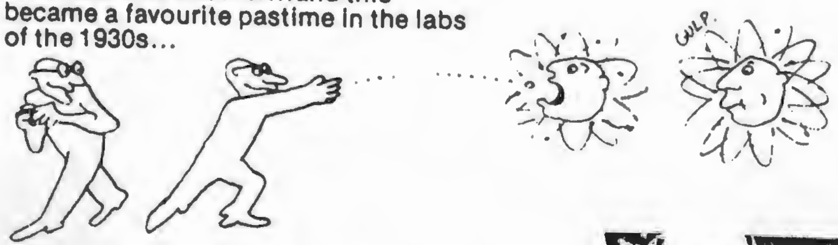
Scientist are funny people...

Give them an **atom**, tell them it's the smallest thing around and what do they do? Split it in two, of course. Just to rub it in, they'll split the very heart of the atom — the **nucleus!**

The scientists spent the first three decades of the 20th century probing the nature of the atom...

Unlocking the atom, though, proved a tough nut until a Briton called **James Chadwick** discovered a tiny particle in 1932 — the **neutron**...

By bombarding atoms with neutrons scientists found they could turn one chemical into another...and this became a favourite pastime in the labs of the 1930s...



Among the most skilful neutron-tossers was the Italian Enrico Fermi...

One day they tried bombarding the nucleus of a uranium atom... and it disappeared! Something was up...

In 1939 an Austrian physicist, Lise Meitner, rescued the scientific community from going crazy by suggesting the uranium atom had *split in two*...a process she called **FISSION**

Ms Meitner's decisive role in this historic achievement was rewarded with a Nobel Prize...for her ex-partner Otto Hahn!

A fission reaction

A neutron hits the nucleus of a uranium atom...

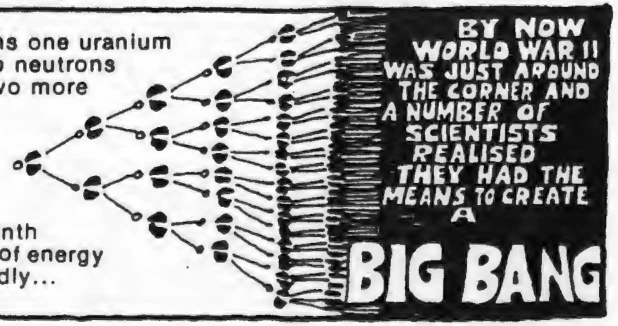
...the nucleus absorbs the neutron but becomes unstable...

...and splits in two, releasing some energy + 2 or 3 new neutrons...

The release of fresh neutrons opens up the prospect of a CHAIN REACTION...

One neutron fissions one uranium atom, releasing *two* neutrons that can produce two more fissions, releasing *four* neutrons etc etc...

The fissions occur every 50-billionth of a second so a lot of energy is released very rapidly...



Radiation means the emission (sending out) of rays of light, heat or atomic particles(at the speed of light).

Since 1945, when the first atomic bomb was dropped on Hiroshima, there has been wide public awareness of the dangers of atomic radiation. During the 1950s in particular there were many demonstrations in Britain to 'Ban the Bomb'.

A substance which emits atomic radiation is termed 'radioactive' and there are a number of radioactive substances. The earth has a natural background radiation and this is measured on the radiation scale at 0.1 'rads' a year. 1 000 rads is needed to kill outright, but only 50 may cause cancer. The safe level accepted in industry, where radioactive substances may be used, is 0·6 rads. There has been concern since 1945 that the testing of atomic bombs (the French and Chinese carried out tests in 1972) may raise radiation to a dangerous level. Radiation can be passed on down food chains, thus cows eating affected grass can pass on radiation to people who drink the milk.

Over-exposure to X-rays is known to be dangerous. Particular care against radiation needs to be taken by women in pregnancy, for the unborn child can be affected.

Atomic war poses one threat. But radiation results every day to a small degree from the running of nuclear power stations, the use of radioactive material in industry and medicine, and the disposal of atomic waste (much of which takes a very long time to lose its radioactivity, a period known as its 'half-life').

Under careful control atomic energy is a servant of Man and could work for our future good.

How dangerous is radiation?

Very heavy elements, like uranium, are unstable and can break apart. When this happens they emit radiation. Many natural substances are weakly radioactive, but some nuclear reactor by-products give off intense radiation.

Just how this might affect a human is still a highly controversial issue – despite considerable research in recent years. However, it is not disputed that too much radiation will ultimately kill a person.

A question of degree? In a bid to quantify the problem, radiologists have developed a measure of radiation called a 'rem'. They reckon a single dose of 600 rems is fatal, that 100 will cause radiation sickness and that 0.5 is the maximum annual dose to which people should be exposed. Above these levels, the body's complex molecules can be disrupted. Tumours can be caused, blood diseases like leukaemia can be produced, and even reproductive organs can be affected.

However scientists still disagree about the exact doses which might produce such effects. In fact, some question if there can ever be a safe dose of radiation at all. 'Any dose of radiation is an overdose,' the Nobel-prize-winning biologist, Dr George Wald, once stated.

'It is possible that the degree of radiological safety we demand is incompatible with the existence of a viable nuclear industry.'
Dr Irving Leach, New York Medical Centre

These arguments are important when discussing nuclear power, for its fuel cycle can lead to many dangers of exposure – no matter how small. Workers who mine uranium or reprocess spent fuel are affected – and so might be the public when that spent fuel is carried across the country or is dumped at sea or below ground.

Indeed, because radiation is invisible and undetectable, it can arouse particularly vivid fears. As one expert said: 'In insidious silence, radiation can produce medical effects of the kind most dreaded by people – cancer in the living body and genetic mutilations in future generations.'

It sounds alarming, but let us also remember that we are always exposed to radiation – from cosmic rays, from rocks such as granite, and from X-rays used by dentists and doctors. Each year, it is estimated we receive an annual dose of 0.12 rems of radiation – and only 0.1 per cent of that is thought to come from nuclear discharges.

If true, this makes smoking or car driving infinitely more dangerous than living near a nuclear reactor. However, there are scientists who believe this is a complacent view. They argue that the body's reaction to radiation is so delicate that any increase in levels, no matter how small, could seriously and even fatally affect our health.

Are we building bomb factories?

Plutonium is renowned as one of the world's most dangerous substances. Inhaling only a few millionths of a gram is enough to cause eventual cancer, leukaemia or death. And if you were to put together a mere 10 kilograms of it (producing a lump the size of a grapefruit) you would have a bomb with the equivalent force of 100 tonnes of TNT. Set off in a city centre, by terrorists or fanatics, it would demolish several blocks of buildings.

The thought is a frightening and disturbing one – especially when we realize that power stations already manufacture several tens of thousands of kilograms of plutonium each year. A minute fraction of that, wrongly used, would be enough to cause havoc.

How simple would it be? Dr Bhupendra Jasani, of the Stockholm International Peace Research Institute, has warned: 'Making reliable fission weapons for the military is complicated, but a crude, inefficient nuclear device is not beyond the capacity of a small group of people.' Indeed, a recent report pointed out that if terrorists obtained plutonium, they would only need equipment that was 'no more elaborate than that used by criminals to manufacture heroin' to prepare an A-bomb. The task would cost a mere £10,000 and could be undertaken by only three or four people.

Others feel these fears are exaggerated. For one thing, the plutonium produced by civil reactors contains isotopes that limit its use as an A-bomb fuel. (The military use special reactors which are refuelled at great speed in order to obtain pure bomb-type plutonium.) This makes it less likely that terrorists could use the plutonium from a civil reactor to build an atom bomb, although this would not be, as was once believed, an impossible feat.

Obtaining that plutonium would also be extremely difficult for it would certainly be well guarded. 'Anyway, there are much easier ways to kill large numbers of people – such as introducing poisons into ventilation systems,' one leading US expert, Professor Bernard Cohen, has suggested.

But opponents fear that it may simply be enough for terrorists to make people believe that they have the plutonium, in order to achieve their aims.

The lost plutonium? Although power plants keep careful stock of their plutonium, tiny amounts do get lost – and these accumulate. For instance, between 1970 and 1977, a total of 96 kilograms was 'lost' through accounting errors at Britain's Windscale (Sellafield) plant. It is possible that criminals could convince the authorities that they had obtained some and so hold them to ransom.

One suggested answer is to 'spike' all plutonium with ferociously radioactive materials that would quickly kill those not properly equipped to handle them; this would remove the risk of threats, either real or bogus. However, the solution itself would be rather hazardous and would probably not deter an irrational terrorist determined to become a martyr.

The human factor?

An accident at a nuclear plant – like any other mishap – can usually be squarely blamed on human error. But mistakes with reactors can have particularly destructive consequences, so great effort has to be made to reduce such risks as much as possible.

As a result, nuclear engineers have designed plants with hundreds of different safety systems, many of which duplicate each other.

'If anything can go wrong, it will go wrong.' Murphy's Law

To err is human? 'Between paper and practice stand people,' says Sir Alan Cottrell. 'People who – in the nuclear industry – weld up steel structures, fit and test valves and pumps, load and unload fuel rods, check the quality of materials, and components, read instruments and press buttons in control rooms.'

And like other people, these technicians and workers sometimes cut corners, and make judgments about vague instructions in either a satisfactory or an unsatisfactory way. The results can be alarming.

For instance, the Windscale fire was actually caused by a scientist raising power levels too quickly because he thought – in part as a result of poor reactor instrumentation – that the core temperature was too low.

More bizarre was an incident at the Brown's Ferry nuclear reactor in Alabama in 1975. There an electrician carried out a cable inspection – using a candle for light! In the process he set off a blaze that spread round the plant, lasted seven hours, knocked out five emergency core-cooling systems, and put the station out of action for 18 months, at a final cost of 40 million dollars.

Design faults But operators and workmen are not necessarily the only culprits. Sometimes over-elaborate safety designs or bad construction can lead to accidents – such as the one at the Enrico Fermi reactor near Detroit. There part of a safety system – added at the last minute at the insistence of the atomic safety authorities – broke apart, and several pieces blocked the reactor's cooling system. The result was a near devastating meltdown of the plant.

And although the Three Mile Island accident in 1979 was largely blamed on human error, there was evidence that operators had been badly confused by over 100 alarm bells ringing simultaneously, and the multitude of dials and controls giving madly fluctuating readings.

Trying to design safe plants which at the same time can be easily operated, while causing only remote risks of accidents, is a difficult task. The nuclear industry believes it has overcome this problem. Opponents doubt if they ever can.

A cheap fuel?

When Allied forces dropped atom bombs that destroyed the Japanese cities of Hiroshima and Nagasaki in 1945, a stunned world suddenly became aware of a force that seemed to have unlimited potential. Surely, thought politicians, every nation would one day be able to tap that power and use it to solve their energy problems.

Utopian dreams? Such optimism was understandable. After all, the energy contained in a single kilo lump of uranium, when burned in a nuclear reactor, releases energy equivalent to that provided by the burning of 3,000 tonnes of coal in a conventional power plant.

Realizing this, confident scientists and politicians quickly began to make grandiose claims about the future of nuclear power. They envisaged constructing whole groups of nuclear reactors which would supply nations with all their power and for only negligible costs. Early publicity even claimed that nuclear electricity would be too cheap even to monitor.

'The day is gone when nations will fight for oil,' claimed the prize-winning author David Deitz in his 1945 book, *Atomic Energy in the Coming Era*. He was backed a year later by a leading US lawyer, James Newman, who helped draft the country's Atomic Energy Act in 1946. 'This new force offers enormous possibilities for improving public welfare, for revamping our industrial methods, and for increasing the standard of living,' he said.

Soaring costs Sadly, however, nuclear energy has not proved to be that easy to exploit. While reactors indeed use fuel that is very cheap, building a nuclear power station is anything but cheap. Installing the extremely complex safety and emergency equipment required has sent construction costs spiralling.

Costly methods had to be found to contain radiation, to provide emergency cooling in case of accidents, to monitor automatically the highly radioactive cores, to refuel the reactor while it was still in operation, and to build the giant concrete and steel domes over the reactor to hold in any serious fuel and waste leaks.

As a result, construction costs soared far above those of traditional power plants and the price of electricity from nuclear power has remained at about the same level as that provided by traditional generating plants.

Increasingly, engineers have chosen to build very large nuclear power plants to make them most economical. Unfortunately, this can lead to astronomical leaps in costs when design errors have been made.

'The capital cost of a nuclear power station, if spent instead on energy saving, would save three times more energy than the station would produce in its lifetime.'
Sir Martin Ryle, Astronomer Royal

How safe is nuclear waste?

Inside a reactor, nuclear fuel undergoes remarkable changes. Its uranium breaks down, and apart from releasing neutrons and energy, it turns into many different elements including strontium, caesium and krypton.

Dealing with this spent fuel – which has to be removed when a reactor is refuelled – is one of the trickiest and most controversial aspects of the nuclear industry. For one thing, the spent fuel is extremely radioactive. But it also contains valuable materials such as plutonium which can be used again as fuel.

Reprocessing Nuclear engineers have to find ways to extract that valuable fuel without risk. This is not easy and can only be carried out at special chemical complexes – known as reprocessing plants – like the one at Windscale (Sellafield) in Cumbria.

Environmentalists view these reprocessing plants with great suspicion and allege they are dangerous sources of deadly pollution. Indeed, the environmental group Friends of the Earth claims that the reprocessing of nuclear fuel 'is probably the most hazardous of all nuclear activities'.

Different wastes, different risks? Before looking more closely at these claims, it is worth discussing the make-up of nuclear waste in a little more detail. In fact, there are three different types of waste: high-, medium- and low-level, each graded according to its radioactivity.

Low-level waste includes contaminated clothing and equipment, while medium waste is similar, although slightly more radioactive. Low-level waste is generally packed in drums and buried in shallow trenches or dumped at sea.

This latter practice – even though it involves relatively weak radioactive waste – is highly controversial and has been denounced at international meetings, including some organized by the United Nations.

Many countries – most recently Belgium and Switzerland – have abandoned the practice. Others, such as Britain, have attempted to continue but have been blocked by action by transport union workers. 'We seem to have left ourselves with two choices – either we destroy this planet by pressing a button (starting a nuclear war) or we get slowly poisoned to death by dumping nuclear waste in the sea,' said James Slater of the National Union of Seamen, which banned nuclear waste dumping in 1983.

At present, medium waste is stored at nuclear plants, but one day may be buried underground.

However, the most controversial type of waste is undoubtedly the high-level variety (although a great deal of public confusion exists about the different types). This is made up of extremely radioactive materials, some with half-lives of several thousand years. (The 'half-life' of a radioactive substance is the time a lump takes to decay to a piece only half as big. For instance, one kilogram of plutonium will decay to a half-kilogram piece in 24,000 years.)

Dealing with high-level waste has caused the nuclear industry many headaches. At present, tanks of it – left over after the uranium and plutonium have been removed from spent fuel – are carefully stored above ground and must be monitored, and closely supervised, at all times. Nuclear industrialists think this is acceptable for the moment, but admit that a safer, permanent solution will be needed very soon.

'If the Romans had developed nuclear power, we would still be guarding their radioactive waste.'
Friends of the Earth

'The high level liquid waste from the entire British nuclear programme is equivalent in volume to two average sized detached houses.'
Lord Sherfield, scienti

Storage of nuclear waste [illegible]

By CHRIS ERASMUS
Science Reporter

IF THE ancient Egyptians, with their limited technology, could build pyramids to last 10 000 years, then it was surely possible for modern man to store radioactive wastes safely for thousands of years, Dr J P Hugo, the Atomic Energy Corporation's executive general manager for nuclear fuels, said at the end of the international Radwaste '86 conference in the city yesterday.

Dr Hugo said the storage of radioactive wastes from commercial nuclear power plants was a proved and safe technology.

He said the debate in the industry on various options on the storage of radioactive wastes did not imply the industry did not know what it was doing.

"I must admit, however, that the storage of high-level radioactive wastes has yet to be proven on a commercial scale.

"I simply can't understand why people persist with this irrational fear of nuclear wastes when, for all practical purposes, we have the technical side of the problem of storage wrapped up," Dr Hugo said.

Project to detect acid rain

Argus Foreign Service

LONDON. — A new ecological project, supported by the European Comission, hopes to provide early warning of the danger to forests and woodlands from acid rain before the vegetation shows any sign of damage.

Headed by the Institute of Terrestrial Ecology at Lancaster and Edinburgh universities, a team of scientists from Britain, Holland and West Germany are seeking a simple method of early diagnosis so that corrective measures can be introduced before the death of trees and plants is inevitable.

Six monitoring sites have been identified, two in each country, where the team will measure the impact of the chemical cocktails that come under the umbrella name of "acid rain".

The three main components to be monitored are the levels of sulphur dioxide, ozone and the degree of acidity in the rain and water.

Studies ranging from surveys from spacecraft to laboratory analyses of the soil, water and vegetation will be repeated through changing weather conditions over the next few months.

1-m could die after Chernobyl fallout

ANAHEIM (California). — More than one million people throughout the world could develop cancer due to exposure to radioactive fallout from the Soviet Union's Chernobyl nuclear accident and half that number would die from it, a US scientist has predicted.

Dr John Gofman, a professor of medical physics at the University of California at Berkeley, said previous estimates of the fallout's effect were based on false assumptions about radiation and cancer risks.

Malignancies

"In the population inside and outside the Soviet Union, the total number of malignancies will be somewhat over a million, of which half of them will be fatalities," Professor Gofman told a news conference before delivering results of his study to the annual meeting of the American Chemical Society in Anaheim.

He estimated that 424 300 people in the Soviet Union and 526 700 in Europe and elsewhere would develop cancer over a 70-year period as a result of being exposed to radioactive caesium from the nuclear power plant accident last April.

He said another 19 500 would develop caesium-caused leukemia and an unknown number would develop thyroid and other cancers from additional radioactive substances in the fallout.

Estimates

Professor Gofman's figures were more than five times greater than the highest previous estimates of possible deaths resulting from the Chernobyl disaster.

Western scientists have predicted from 2 000 to 75 000 premature deaths resulting from the accident, which killed 31 people and forced evacuation of 135 000 people in the Ukraine.

Professor Gofman said the effects of low-level exposure to caesium radiation were discounted by scientists who based their assumptions on inaccurate data.

He said estimates presented at a meeting of the International Atomic Energy Agency last month included only cancer cases within the Soviet Union and were based on risk factors that were far too low.

Professor Gofman said the IAEA findings "said nothing about the fact that outside the Soviet Union there would be at least as large a number of cancers as inside the Soviet Union."

Professor Gofman, who conceded his estimates would be discounted as highly exaggerated by many scientists, said he did not question the amount of radiation dosages reported by Soviet officials at the forum but sharply disagreed with the amount of cancer risk estimated by the IAEA. — Sapa-Reuter.

Koeberg plant an 'economic disaster'

Environment Reporter

THE Koeberg nuclear power station has been an "economic disaster" and no new nuclear power stations should be built, claims Koeberg Alert, the anti-nuclear power lobby.

Instead, money should be spent on researching alternative energy resources to meet the needs of the rural population, "where South Africa's real energy crisis is to be found".

However, Escom has responded by saying that although no decision on new nuclear power stations is likely in the foreseeable future, present investigations will allow sufficient time for "thorough and co-ordinated" research, including economic viability.

Koeberg Alert said construction of a nuclear power station in sensitive areas would damage the environment and that the effects of any major nuclear accident would be "catastrophic".

The organisation has called for a full investigation into the cost of any new nuclear plant and claims this was not done in the case of Koeberg, "with the result that this plant is an economic disaster.

"According to figures released in Parliament in 1984, Koeberg has turned out to be the most expensive option for supplying electricity to Cape Town with electricity costing three times that from coal power stations in the Transvaal.

Ireland wants UK nuclear plant shut

DUBLIN. — Ireland's Deputy Prime Minister has called for an international campaign to persuade Britain to shut down the Sellafield nuclear reprocessing plant after the accidental discharge of low-level radioactive waste into the Irish Sea.

Mr Dick Spring, who is also Ireland's Minister of Energy, announced the campaign on Thursday, hours after 50 000 gallons of low-level waste containing mainly radioactive cesium was released into the sea from the plant on England's north-west Cumbria coast.

British Nuclear Fuels, which operates Sellafield, said yesterday that an "operational error" led to the waste being discharged from a storage tank before being tested for radiation levels. — Sapa-AP.

Fossil fuel dangers

Like a blanket that keeps a sleeper warm, carbon dioxide in our atmosphere absorbs and holds heat. And every year we pump more and more carbon dioxide into the air by burning fossil fuels, such as coal and oil, which contain carbon. One day it is feared we may pump out so much that the earth could become dangerously hot. Glaciers and ice fields would melt, low-lying countries would be flooded, and the world's climate would be utterly changed.

> *'Temperature increases are likely to be accompanied by dramatic changes in precipitation and a rise in global sea level.'*
> *US Environmental Protection Agency*

That sounds like a scene from a science fiction disaster movie – but many scientists are now worried that it could come true. There is evidence that carbon dioxide levels in the air have risen by more than 40 per cent in the past 100 years – because of industrialization and increased coal- and oil-burning.

The greenhouse effect Every hour more than 500,000 tonnes of carbon are burned around the world by car engines and factories, and are pumped into the air as carbon dioxide. As a result, the atmosphere is likely to retain more and more of the heat we get from sunlight, instead of radiating it back into outer space. This is called the 'greenhouse effect' – for that is how greenhouses keep plants warm. One day the entire planet could become as hot as a greenhouse.

Already, the Environmental Protection Agency of the United States government has issued its own stark warning – that global temperatures could rise by up to 6 deg C next century, enough to cause widespread havoc.

Weather patterns around the world would be completely altered; rainfall patterns would change; rivers would swell or dry up; and with the melting of the ice caps the level of the seas would rise dramatically. Indeed 'we may get into trouble in ways we have barely imagined', warned the US National Academy of Sciences.

Other scientists have been more cautious, suggesting that temperatures may not rise that rapidly because the oceans will absorb much of the extra heat. Nevertheless, there is broad agreement that the greenhouse effect will soon become a serious problem.

Acid rain Unfortunately, fossil fuels have other unwelcome side effects. Factories which burn coal and oil produce acidic oxides of sulphur and nitrogen. These gases dissolve in the clouds and later fall to the ground as acid rain.

Already there have been reports that acid rain has killed all aquatic life in hundreds of lakes and rivers in Canada, Sweden and America; released lead from water pipes; damaged soil and eroded buildings; stunted forests; and increased respiratory illnesses.

Many of these claims still have to be investigated, but it is clear that the problem is growing. The difficulty for governments trying to control acid rain is that the factories responsible for it are often not in the same country. Sweden, for instance, blames Britain for the acid rain which falls on its lakes. Trying to resolve questions of responsibility in such circumstances can take a long time.

No easy answer? It would seem that even standard 'safe' fuels, like oil and coal, have unpleasant side-effects and, like nuclear fuel, can be regarded as potential threats to the environment. Only renewable energy sources, that tap the power of the sun, wind and tides, are both safe and will not run out. But they too present problems.

What's wrong with coal?

What's the rush? Why not stick to coal power, especially in a country like South Africa, which has zillions of tons of coal on hand?

The nuclear fever must be for hidden reasons, claim the knowledgeable, and the cynical. Either there is some sort of nuclear fixation, a keeping-up-with-Uncle-Sam mentality, or there is an underlying military purpose.

Maybe, maybe. Who's to know what tunnels of psyche and of strategy lead off the corridors of power? But if there's an underlying military aim, it's lying a long way under. That's not necessarily to assume any great purity of soul; merely that where science is advanced and resources considerable nuclear energy is of only marginal help to nuclear militarisation.

True, the reasons Escom gives for going into Koeberg -- such as that it will liberate the Cape from dependence on imported Transvaal power - do not ring with urgent conviction. But then, they aren't meant to. Escom makes it clear that it sees Koeberg as a prudent piece of foresight rather than a compelling immediate need -- and it will also save much of the wastage which currently goes into long-distance electricity transmission.

Nuclear power should turn out cheaper -- either already or in the near future. In America, according to Consolidated Edison's figures, nuclear powered electricity costs 1,5c per Kilowatt-hour; coal-powered 2.3c; and oil-powered 4c. The trouble is that it's virtually impossible to work out the figures accurately, since a large part of nuclear costs is veiled by government research expenditure and capital expense on uranium enrichment.

In South Africa, unless Reagan does an about-turn on Carter's refusal to supply processed fuel pellets until SA signs the non-proliferation treaty, Koeberg may have to rely on the limited supply from Valindaba, which is being extended for the purpose, but is still a long way from being able to power Koeberg effectively.

Whatever the actual reasons, there are cogent human and environmental considerations. Nuclear power may yet cause destruction, but coal already has. Literally thousands of people have been killed mining it, and if the victims of black-lung disease are included the figure may be millions.

Coal is king-size pollutant -- and a coal station Koeberg's size would burn 16 000 tons a day. It also produces its own output . . . what else but radiation! Coal's radioactive habits have somehow been forgotten in the furore over nuclear radiation, but they are substantial. General Austin Betts, one-time Pentagon warlord turned nuclear industrialist, calculates that the radioactivity in coal ash is 180 times as much as that which would normally come from a comparable nuclear plant. Either his calculator batteries were running flat or he's on to something that could be big. In any case it seems to be established that depending on the type of coal involved, a coal station directly emits more or less the same quantity of radioactivity as a nuclear station of equivalent power.

And coal is running out. Precisely *when* it will run out, no-one knows. Some projections allow as much as 200 years; others less than 100.

But the real question, as Sir John Hill, chairman of Britain's Atomic Energy Authority, points out, is not when the last lump of coal, or the last drop of oil, is mined. Both coal and oil are needed for chemical purposes for which there is no substitute, like making plastics and fertilisers. Moreover, there will come a time when mining them is a net energy drain. That is; no matter how high the price and the operating company's profit, the amount of energy required to extract increasingly inaccessible reserves will be greater than the energy those reserves supply.

What have we done to the rain?

Tall smokestacks push sulphur dioxide and nitrogen oxides from power stations high above the lungs of city dwellers. This has solved local smog problems, but means that the pollution is blown somewhere else. Some comes down as gas relatively near home, corroding metals and buildings and damaging crops. The rest turns into acids in the atmosphere and falls as rain and fog, hundreds of miles away, poisoning lakes and forests. This 'acid rain' has caused problems in Europe and Russia, parts of Canada and the United States, and even in Brazil.

The world's most acid rain recorded fell in Pitlochry, Scotland, in 1974. It was sourer than vinegar. The average raindrop in Europe is not nearly as acid as that – but is still up to twice as acid as it was 30 years ago.

Lakes and forests Acid rain does most harm in areas like southern Sweden and Norway, where the soil is too thin and low in lime to neutralize the acid in the rainwater which falls on to it. This pours off the land into the lakes and rivers, setting off a chain reaction which kills most life. The Swedes say 18,000 of their lakes are at risk, and fish have died out in lakes and rivers in Scandinavia, Canada, the United States and Scotland.

In other areas, many scientists believe acid rain is killing the forests. West Germany says that a third of hers are dying – and Austria, Switzerland, the Netherlands, East Germany and Czechoslovakia are worried about theirs.

Whose responsibility? The acid rain debate today centres on who should do what about it. The Swedes spend millions of pounds a year liming their lakes to make them less acid. A Swedish Ministry of Agriculture report in 1982 insisted that this is no permanent solution – the problem must be solved at its source, in the power stations abroad from which 70% of their sulphur pollution comes.

The technology exists to halve Western Europe's sulphur dioxide and nitrous oxide emissions by the year 2010 – but it could add at least 5% to electricity prices to do so. This makes countries such as Britain, Europe's largest acid rain exporter in the early '80s, cautious. Since everyone needs electricity, the expense would 'lower everyone's standard of living', according to the Chairman of Britain's Central Electricity Generating Board, Sir Walter Marshall, in 1983. 'It would be tragic to do this without understanding exactly what we are doing.'

Sceptics point out that the science of acid rain is complicated. Why penalize power stations until we are sure they are the culprits? There is no doubt, for example, that some of the trouble is caused by car exhausts. They also release sulphur dioxide and are the main source of nitrogen oxide pollution. Some scientists believe cars, not power stations, are the real killers of the German forests.

Meanwhile, America's largest electrical power system, the Tennessee Valley Authority, has already halved its sulphur dioxide emissions. 'Concern about bills and job prospects are very real,' says its Director, David Freeman. 'But they must give way to concern over life itself. The typical consumer is now paying $4 on each bill for cleaner air.'

Is acid rain, as *Nature* magazine once put it, 'a million dollar problem with a billion dollar solution'? The importing countries see things differently. 'The Black Forest is beyond price,' said the Prime Minister of Baden Wurttemburg, West Germany, in 1983. 'We cannot wait for a perfect understanding of the acid rain phenomenon before moving to control it,' commented a Canadian official in February 1981. 'How many more lakes have got to die before we get the message?'

Time to stop dropping acid?

In Norway fish have died out in over 13,000 square km of lakes. In Germany's Baden-Wurttemberg region – which includes the famous Black Forest – half of the trees have been damaged: the same has happened in Bavaria. The culprit is acid rain. It threatens to give us one of the worst environmental headaches imaginable over the next decade. Agricultural productivity may be impaired and magnificent buildings like the Taj Mahal and the Acropolis are already suffering severe damage.

Acid rain is formed when sulphur dioxide and various nitrogen oxides combine with rain water. Pure rain water has a pH (the standard measure of acidity) of 5.7. Rain over much of Western Europe and the industrial American states has a much lower pH (and thus higher acidity), sometimes dropping as low as pH3. The increase in acidity in fresh waters leads to impaired reproduction in fish, with salmon, trout and roach being particularly susceptible. Once the pH falls below 5.5 small species of mollusc and crustacean disappear and no fish survive once it falls below 4.5 (in 15 states east of the Mississippi the rain has pH values between 4.8 and 4.1.)

Whose problem? The main sources of the emissions which turn to acid rain are electric power stations and oil refineries. Britain is Europe's biggest emitter of sulphur dioxide (producing over 4 million tonnes in 1982). Over half is said to come from electric power stations. But of this huge quantity only a third falls on Britain. The rest goes elsewhere, ignoring state boundaries and the niceties of international law. Three-quarters of the acid rain which falls on Norway and Sweden comes from other countries. Half of Canada's drifts over from the United States.

Some scientists and industrial leaders say the scale of the problem has been exaggerated. It is undoubtedly difficult to separate the effects of acid rain from those of other aerial pollutants, and so far, claim some scientists, evidence which links acid rain to decreased forest productivity is circumstantial.

Big industry: time to come clean? Every year between 30,000 and 90,000 tonnes of lime (a neutralizing compound) is spread on Swedish lakes to counter the effects of acid rain. But this is no long-term solution. The only long-term, viable and permanent cure is for the industries responsible for acid rain to reduce their emissions. Power stations could use fuels with lower sulphur contents and gases which are being released into the atmosphere can be 'scrubbed' to remove the sulphur dioxide.

But this is an expensive process. The Central Electricity Generating Board in Britain has threatened to increase electricity prices by some 15% if it is forced to reduce sulphur dioxide emissions. Some environmentalists say this is a scare tactic. But if it isn't, will the British consumer be prepared to pay to save the Swedish salmon?

'Acid rain is responsible for damage to nature on a vast scale.'

European Parliament's Environment Committee

Renewable energy

Each year, every human being, on average, uses energy equivalent to the burning of approximately 3 tonnes of coal. This power is used for heat, transport and electricity. At the moment it comes from the world's three principal energy sources – oil, coal and uranium, but reserves of these are quickly running out.

Some politicians and scientists believe the only answer is to build more nuclear reactors. Others want to exploit renewable energy sources that cannot run out and do not pose any threats to the environment. These include the sun, wind and tides.

Solar power Of these, solar power has perhaps the greatest potential – for, every day, energy from the sun pours down on our planet. Indeed as much solar energy falls on the earth in an hour as all the world's nations consume as fuel in a whole year. It is a remarkable free gift, and is likely to last for ever. Unfortunately its exploitation is no straightforward matter.

'The energy crisis is a myth.' Colin Sweet, Centre for Energy Studies

One problem is that, although plentiful, sunlight does not actually make things very hot. It is used in some countries – such as Israel – to heat water for homes, but generating electricity requires a temperature of several hundred degrees. To reach this, sunlight must be concentrated in some way – usually by using very large mirrors. These can only operate in direct sunlight and must be moved as the sun itself moves across the sky – a tricky procedure that also uses up energy.

One answer may be to build solar ray collectors in space and then beam their power to the ground. Such assemblies are possible but would require costly and difficult construction, and are unlikely to become practical undertakings this century.

Wind power For more than 1,000 years, mankind has been exploiting the energy of the winds. Indeed, until the last century, wind was a major source of power, harnessed by windmills that milled, ground and pumped, as well as by sailing ships.

But these machines were relatively inefficient, and were replaced by steam engines and later by diesel and electric motors. However, some scientists now believe that modern technology can help design improved windmills able to convert wind energy into electricity. Already, many countries have designed prototype wind generators – giant groups of rotor blades mounted on towers to catch gusts that can travel at up to 120 kph. To survive such conditions, the rotor blades must be very strong, but they must also be light so they can revolve easily. Finding the right materials for the blades is a major problem in building wind generators.

At the moment, scientists do not believe that wind generators can provide much more than 500 kilowatts of power, enough for a very small town. To produce larger amounts, many hundreds of giant towers would have to be built, causing major disruptions to the countryside.

Wave power Every day, the world's coasts are battered by waves of enormous power.

Surely, say researchers, we can harness that incredible energy and use it to generate electricity. Indeed, they point out that in deep seas, a one-metre section of a wave front can carry 100 kilowatts of power.

The trouble is that – like wind generators – wave machines must be made of very strong materials to survive their hostile environment. But they must also be light so that their individual parts can move easily and turn the turbines.

'If a wave converter is to survive constant battering – in the North Atlantic it would encounter between two and three million waves each year – it must be massively built. Yet if it is over-engineered it will be expensive and unable to compete with other sources of energy,' points out Dr Michael Flood of Friends of the Earth.

As yet, scientists have not managed to balance these different demands but still insist that wave power, and solar and wind power, have enormous potential. As designs are continually improved they should at least reduce our dependence on present traditional energy sources.

A new problem?

Did pollution finish off the Roman Empire? The Romans stored wine in lead vats and some scholars think lead poisoning weakened their minds and lay behind the fall of their civilization. High lead levels have been found in Roman skeletons. Other historians suggest that Napoleon, Ivan the Terrible and Charles II may all have died of mercury poisoning.

Air pollution has been with us since the first caveman choked in his neighbour's smoke. In 1306 Edward I banned the burning of sea-coal by London craftsmen, because it made 'so powerful and unbearable a stench'.

No sun on weekdays? Worse was to come with the Industrial Revolution. A French visitor to Manchester in 1835 wrote: 'A sort of black smoke covers the city. Under this half-daylight 300,000 human beings are ceaselessly at work.' Ten years later, Friedrich Engels had sharp things to say about the city's rivers: 'At the bottom flows, or rather stagnates, the Irk, a narrow, coal-black, foul-smelling stream.' Across the Pennines in Leeds, you could only see the sun on Sundays.

Repeated cholera epidemics in London in the nineteenth century eventually led to the first attempts at sewage control. During the early twentieth century people increasingly realized that polluted air, too, was a killer. In 1930, 6,000 people became ill because of smog in the Meuse Valley, Belgium, and 60 died. American cities like Pittsburgh, so dark that drivers sometimes had to use their headlights at midday, began to impose smoke controls in the 1930s and '40s. London followed suit after the Great Smog of 1952. Smokeless zones were enforced and industries and power stations began to build tall smokestacks to throw the pollutants to the winds. Londoners now enjoy 70% more sunshine in December than they did in 1958.

'The annual loss of life from filth and bad ventilation is greater than the loss in any wars.' — Edwin Chadwick, social reformer, 1842

As old problems disappeared, new ones emerged. In 1943 people in Los Angeles became aware of a yellow-brown haze which made their eyes smart. By 1962 Los Angeles suffered from photochemical smog 212 days in the year. The problem was eventually traced to a chemical reaction between car exhaust fumes and sunlight. Photochemical smog plagues cities all over the world – only countries with dull climates, like Britain, escape. In the '70s America and Japan moved to control vehicle fumes by fitting special converters to car exhausts.

Discovering the environment The pace of pollution quickened with the industrial boom in America, Europe and Japan after the Second World War. Japan's heavy metal tragedies in the '50s alerted people to new dangers, while Rachel Carson's book *Silent Spring*, published in 1962, painted a picture of a countryside destroyed by pesticides. By the end of the '60s the environment was in fashion – the *New York Times* carried over 1,600 articles on environmental issues in 1970, eight times as many as it had in 1960.

It was becoming clear that pollution could not be beaten by individual nations on their own. Pollutants thrown into the sea could end up on another country's shores; gases dispersed on the winds could poison another country's lakes. Some pollutants might even be affecting the Earth's atmosphere. In 1972, 113 countries met at a UN conference in Stockholm to discuss these problems – a landmark in itself. But in the 1980s, most of them still remain unresolved.

Everybody's problem?

'If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically and more vulnerable to disruption than the world we live in now,' warned the American *Global 2000* report in 1980. Pollution is not the only environmental threat to our planet – but it may be the one we in the West can do most about.

We cannot live without creating pollution – even if it is only the smoke from the wood-stove on a self-sufficient farm. But we can do a great deal to reduce it. It will demand changes – for even at a slow rate of growth, according to another report in 1980, present pollution controls in the industrialized world are not strong enough to stop pollution increasing.

So what can we do? First we can ask the questions. What chemicals are we using – and are they worth it? Are conditions at home or work really safe, or is someone taking shortcuts? What pollutants are particularly dangerous to small children? What is the local factory putting into the river and the air? What is finding its way onto the local rubbish dump? If something is wrong you can join up with others to put pressure on industry or government.

Asking the questions Pollution reminds us that humanity is interdependent. The crisp packet I drop becomes someone else's problem; so does the sewage a city flushes untreated into a river; the mercury a factory dumps in the sea; the acids a power station puffs into the air. The fate of the climate or oceans will determine the future of all humanity.

Consumer power Governments all over the world tend to think in the short term – the immediate crisis, the next election. Pollution acts slowly – lakes take years to die and cancers can take decades to grow. Politicians think we won't vote for them if they offer us a cleaner environment rather than a higher standard of living. 'There are no votes in sewage,' they say. But a national opinion poll in the early '80s revealed that one in five voters would readily consider switching their vote to a main party which committed itself to wasting less natural resources.

'Environment is people and peopl[e's] environment.' Aurelio Peccei, Club of Ro[me]

Pollution is linked to our lifestyles. If we want goods we can enjoy for a while and then throw away, industry will produce them for us, taking short cuts to keep the prices down. Are we ready to pay for clean air and water? Do we really want a society where things last? Do we judge ourselves and each other by what we have – or by what we are like? Of course we need money to survive and possessions to enjoy – but how much is enough?

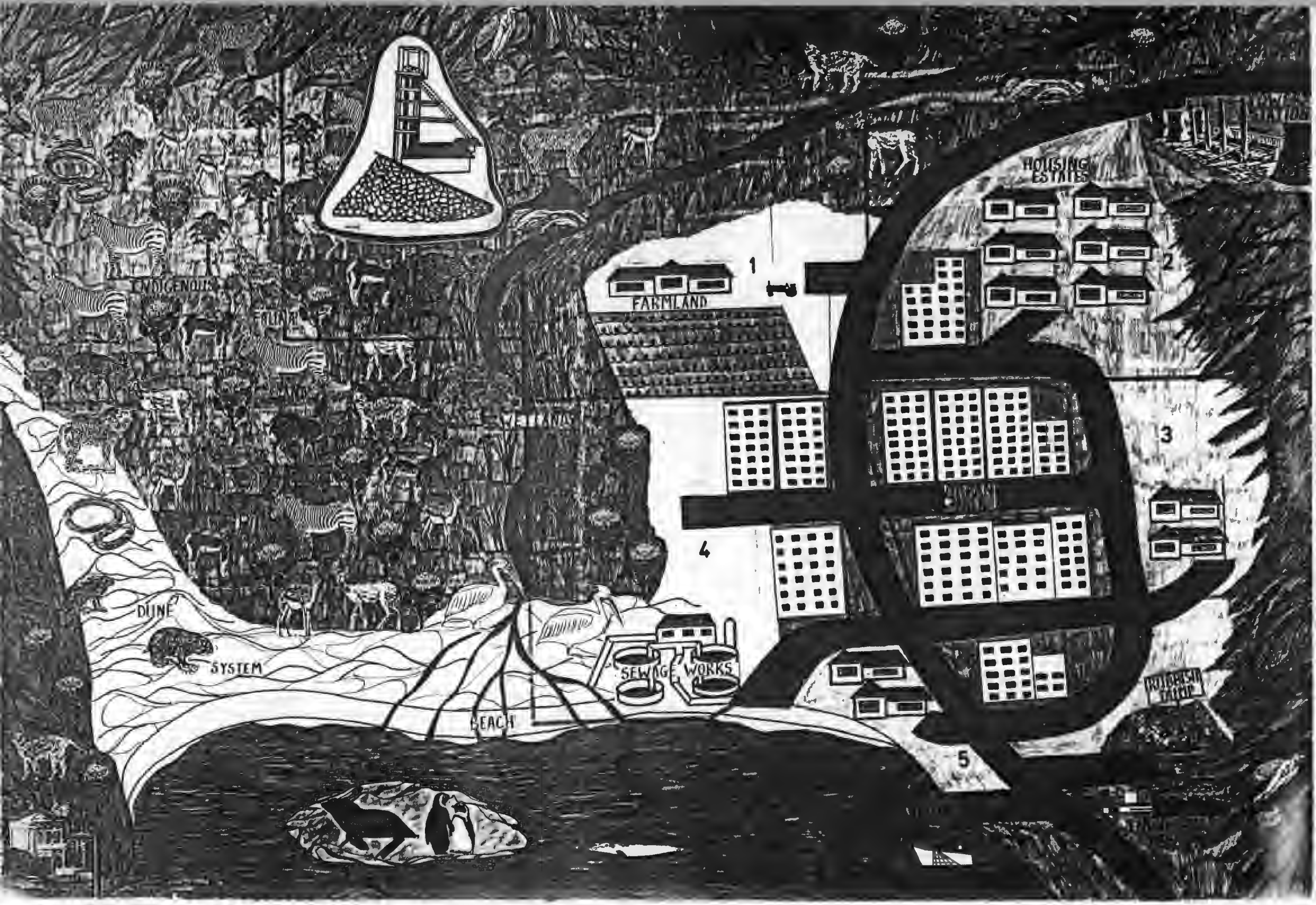
'People's perception of environmental problems has improved,' said the United Nations Environment Programme, in its review of the 10 years since the Stockholm conference. 'It is less clear that many groups have adapted their lifestyles in response.' Whose problem is pollution – someone else's, or our own?

'At root we are all polluters.' Maurice Ash, Dartington Hall Trust

Isolated – but part of an interdependent world?

APPENDIX 4

BASE MAP OF THE FICTITIOUS AREA SIMONSVILLE



HOUSING ESTATES
1
2
FARMLAND
INDIGENOUS
FAUNA
WETLANDS
3
4
DUNE
SYSTEM
SEWAGE WORKS
BEACH
5

APPENDIX 5

ACTION COMPONENT INSTRUCTIONS FOR PARTICIPANTS

(± 100 minutes)

* All participants to sit in groups in a semi-circle facing the management committee.

* Chairperson (i.e. Mayor/Mayoress)of the Management Committee to announce that:

  A special meeting of the Simonsville Town Council has had to be called to debate the following issue, which has arisen out of the report and proposal by the National Electricity Board (NEB).

  The NEB states in its report that the ever increasing energy demands placed upon Eternia, has necessitated the building of another power station. The most agreeable site, geologically and otherwise (according to scientific experts) is the one located near the town of Simonsville (see base map). The NEB has embarked upon an extensive nuclear programme because it believes that "it is the cheapest, safest and cleanest source of energy production available." The NEB also intends to build another 12 nuclear power stations throughout Eternia in the not too distant future. The NEB believes that the Simonsville site is "the best place to build a nuclear power station in Eternia, at the present point of growth in the country. The NEB has also (to prove its interests and concern for conservation) pledged to give R100 000.00 to the Simonsville Town Council, in order that the town may expand and improve the present Nature Reserve area.

The issue at hand therefore is:

(a) **Should the Town Council of Simonsville accept the NEB's proposal to build a nuclear power station in the Simonsville area?**

OR

(b) **Should the Town Council of Simonsville rather opt for exploiting the vast quantities of low-grade coal in Area 6 (Nature Reserve) which now would be economically viable, to use for fuel for a new (additional coal-fired) power station which would be located next to the existing one?**

* Mayor/Mayoress now hands out information files to each group, and instructs them to read through all the documents (± 30 minutes) and to discuss the matter at hand (± 30 minutes). They must also decide upon which proposal they are going to accept (discuss and vote) and be prepared via their group's chairperson to report on why their group supported or rejected the specific proposals. Each group must reach consensus on this issue by voting - (Chairperson : remember has casting vote).

* The chairperson of the Management Committee will ask for a volunteer in his/her group to record how each group voted and which proposal <u>they</u> have accepted.

* Mayor/Mayoress, after 60 minutes has elapsed, announces the end of the discussion. Declares a break - everyone must be back after 10 minutes. He/She then asks the groups to report back upon their discussions. Group 6 (the nature conservationists) will give their report first. Groups 1 - 5 will then present their reports ending off with Group 7's report. (<u>Each member</u> of Group 7 to present his/her own personal choice - each Group 7 member <u>has a vote</u>).

* Report back, recording and voting to last ± 10 minutes (each group having ± 5 minutes to report back).

* After the votes for and against each of the proposals has been added up the chairperson of the Management Committee will announce which proposal has been accepted by the Simonsville Town Council.

* The action component now ends at this juncture. However, the debriefing follows directly after this.

APPENDIX 6

SPECIAL INSTRUCTIONS FOR THE PARTICIPANTS PLAYING THE ROLE OF MAYOR/MAYORESS.

Mayor/ess of Simonsville reads out the following:-

"A special meeting of the Simonsville Town Council has had to be called to debate the following issues, which has arisen out of the report and proposal by the National Electricity Board (NEB).

The NEB states in its report that the ever increasing energy demands placed upon Eternia, has necessitated the building of another power station. The most agreeable site, geologically and otherwise (according to scientific experts) is the one located near the town of Simonsville (see base map). The NEB has embarked upon an extensive nuclear programme because it believes that "it is the cheapest, safest and cleanest source of energy production available." The NEB also intends to build another 12 nuclear power stations throughout Eternia in the not too distant future. The NEB believes that the Simonsville site is "the best place to build a nuclear power station in Eternia, at the present point of growth in the country. The NEB has also (to prove its interests and concern for conservation) pledged to give R100 000.00 to the Simonsville Town Council, in order that the town may expand and improve the present Nature Reserve area.

The issue at hand therefore is:

(a) Should the Town Council of Simonsville accept the NEB's proposal to build a nuclear power station in the Simonsville area?

OR

(b) Should the Town Council of Simonsville rather opt for exploiting the vast quantities of low-grade coal in Area 6 (Nature Reserve) which now would be economically viable, to use for fuel for a new (additional coal-fired) power station which would be located next to the existing one?

You must now read the information files thoroughly (until...) and then discuss, debate and decide upon your group's choice. Your group leaders will have to report back at a later stage giving your choice and the reasons for your choice. You are expected to complete your discussions by ....., after which there will be a break of 10 minutes. The report-back will follow the break.

Report Back (45 minutes)

Group 6 (nature conservationists) will begin the report back, after which you may allow questions from other groups (maximum time 15 minutes). The remaining 30 minutes is for groups 1 - 5 to report back, as well as short individual reports from each member of the Management Committee. Each group's vote must be recorded (1 vote each) together with each Management Committee vote (5 in total).

You should end up with a score of 10. If the result is a 5 - 5 draw, you as the mayor/ess have the casting vote. After all the groups have reported back including the Management Committee - announce Simonsville's decision.

APPENDIX 7

PILOT STUDY QUESTIONNAIRE

UNIVERSITY OF CAPE TOWN

ENVIRONMENTAL EDUCATION HIGH SCHOOL PUPIL QUESTIONNAIRE

The purpose of this questionnaire is to gain information about high school pupils' knowledge and attitudes about environmental education. When answering questions please reflect your own feelings and not what you perceive to be the correct answer. Your responses will not be scored in any way, and are only for the use of the researcher. The questionnaire will be kept strictly private and confidential.

Thank you for your co-operation.

PERSONAL DATA (Please fill in the required information)

1. Surname ....

2. Christian Name/s ....

3. Date of birth ☐☐☐

4. Male ☐ Female ☐ (Please tick the appropriate block)

5. Do you belong to an environmental/conservation group?

   (Please tick the appropriate block) Yes ☐ No ☐

6. If your answer was Yes in the above question, please state which group (in or outside of school) you belong to.

   ....

7. Which of the following subjects do you take? (Please tick the appropriate block/s).

   Accountancy ☐
   Biology ☐
   Geography ☐
   History ☐
   Mathematics ☐
   Physical Science ☐

Environmental Concepts

Read the following statements carefully, and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

8. The term ecology refers to :

a) the study of the natural features of the earth's surface and man's response to them.

b) they study of the origin, structure and composition of the earth.

c) the study of the interralationships between living organisms and their surroundings.

d) the study of the geographical distributions of organisms, their habitats and the historical and biological factors which produced them.

9. The term ecosystem refers to :

a) a system involving the interactions between a community of biotic organisms and their physical surroundings.

b) a system which involves interactions between abiotic elements and their physical surroundings.

c) a system which involves the interactions between gaseous substances and the physical surroundings.

d) a system which involves the interaction between gaseous substances and abiotic elements.

10. The term nature conservation means :

a) the wise use and management of farmland.

b) the wise use and management of urban areas.

c) the wise use and management of all natural resources.

d) the wise use nad management of all man-made resources.

11. R.J. Tanner's 'Spaceship Earth' concept refers to :

a) the fact that earth is part of the solar system and as such should be studied continuously.

b) the earth having limited resources and limited space, and as such creating the need for people to manage their numbers and the earth's resources carefully.

c) the fact that, if and when the earth's resources do 'run out', they can be replenished as easily as refuelling a rocket.

d) the fact that many of the earth's problems could be solved by migration to other planets in the solar system.

12. The 'greenhouse effect' refers to :

a) the tendency towards increasing temperature of the lower layers of the atmosphere caused by an increase in atmospheric carbon dioxide.

b) the tendency towards increasing temperature of the lower layers of the atmosphere caused by an increase in atmospheric hydrogren.

c) the tendency towards increasing temperature of the lower layers of the atmosphere caused by an increase in atmospheric nitrogen.

d) the tendency towards increasing temperature of the lower layers of the atmosphere and by an increase in atmospneric argon.

13. The term 'total environment' refers to :

a) the natural surroundings affecting plants, animals and people.

b) the natural and man-made surroundings affecting plants, animals and people.

c) the natural and man-made surroundings affecting plants and animals.

d) the natural surroundings affecting plants and animals.

14. A food chain refers to :

a) the relationship between edible and inedible plants.

b) the transfer of energy through a series of organisms.

c) the paticular cell-structure within edible plants and animals.

d) the amount of energy stored within a living organism.

15. The term habitat refers to :

a) the natural habitats of living organisms.

b) the natural condition of abiotic elements.

c) the natural place of abode of living organisms.

d) the natural distribution of abiotic elements.

16. The term 'radioactive half-life' refers to :

a) the time it takes for the atoms of a radioactive substance to increase its radioactivity by half.

b) the time it takes for the atoms of a radioactive substance to decay by half.

c) the time it takes for the atoms of a substance to become radioactive.

d) the time it takes for the atoms of a radioactive substance to become non-radioactive.

Environmental Knowledge

Read the following statements carefully and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

17. Radiation is :

a) vibrating electromagnetic energy moving at the same speed as the earth rotating on its axis.

b) vibrating electromagnetic energy moving at the same speed as that of the earth revolving around the sun.

c) vibrating electromagnetic energy moving at the speed of sound.

d) vibrating electromagnetic energy moving at the speed of light.

18. Plutonium is :

a) a radio-active element.

b) a radio-active fuel.

c) a radio-active gas.

d) a radio-active liquid.

19. Acid rain is :

a) rainwater which turns into an acid when it comes into contact with the soil.

b) the combination of sulphur dioxide, nitrogen oxide and water in the atmosphere which produces an acid rain.

c) the combination of carbon dioxide, nitrogen oxide and water in the atmosphere which produces an acid rain.

d) the combination of dust particles in the atmosphere with water which causes an acid rain.

20. Nuclear fission refers to :

a) a nuclear reaction in which an atomic nucleus is split in two parts releasing energy.

b) nuclear reaction in which an electron is split into two parts releasing energy.

c) a nuclear reaction in which a neutron is split into two parts releasing energy.

d) a nuclear reaction in which a proton is split into two parts releasing energy.

Environmental Attitudes (Attitudes towards the environment)

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice place a cross through the appropriate term listed underneath each statement, e.g. ~~Agree~~

21. Nuclear power is dangerous.

Strongly agree Agree Uncertain Disagree Strongly disagree

22. Nature reserves must be protected.

Strongly agree Agree Uncertain Disagree Strongly disagree

23. The air pollution caused by coal-fired power stations justifies their immediate closure.

Strongly agree Agree Uncertain Disagree Strongly disagree

24. Nuclear power is a valuable technological development.

Strongly agree Agree Uncertain Disagree Strongly disagree

25. The continued use of coal in South Africa as an energy source is necessary.

Strongly agree Agree Uncertain Disagree Strongly disagree

26. Nature conservation should be taught as a subject in schools.

Strongly agree Agree Uncertain Disagree Strongly disagree

27. The conservation of historic urban environments is important.

Strongly agree Agree Uncertain Disagree Strongly disagree

28. Saving animals will not save people's lives.

Strongly agree Agree Uncertain Disagree Strongly disagree

29. The exploding population is the greatest environmental problem facing the world.

Strongly agree Agree Uncertain Disagree Strongly disagree

30. The need for environmental conservation is not as important as the need for economic development.

Strongly agree Agree Uncertain Disagree Strongly disagree

31. Recycling waste products is essential in today's world.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

32. Science and technology will solve all our problems.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

33. Pollution is an acceptable price to pay for progress.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

34. Our present lifestyle is the cause of the 'environmental crisis'.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

35. Littering is a serious environmental problem.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

36. Environmental problems will only be solved by the complete political restructuring of society.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

<u>Behavioural Intentions</u>

Read each item carefully. Choose the response which <u>reflects your feeling most accurately</u>. Having made your choice place a cross through the appropriate term listed underneath each statement.

38. I am considering joining an environmental/conservation group.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

39. School pupils cannot do anything against large organisations or government bodies.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

40. I intend reading and finding out more about environmental problems.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

41. School pupils cannot be expected to do anything about environmental issues such as the nuclear issue.

Strongly agree   Agree   Uncertain   Disagree   Strongly disagree

Evaluation of Simulation/Gaming as a Teaching Method

Read the item carefully. Choose the response which reflects your feeling most accurately. Having made your choice, place a cross through the appropriate term listed underneath the statement.

42. How often have you experienced simulation/gaming techniques in high school?

Never   Very seldom   Seldom   often   Very often

43. If you have experienced simulations/games, in which subjects were they "played"?

____

____

____

____

APPENDIX 8(a)

FIRST QUESTIONNAIRE

UNIVERSITY OF CAPE TOWN

ENVIRONMENTAL EDUCATION HIGH SCHOOL PUPIL QUESTIONNAIRE

The purpose of this questionnaire is to gain information about high school pupils' knowledge and attitudes about environmental education. When answering questions please reflect your own feelings and not what you perceive to be the correct answer. Your responses will not be scored in any way, and are only for the use of the researcher. The questionnaire will be kept strictly private and confidential.

Thank you for your co-operation.

PERSONAL DATA (Please fill in the required information)

1. Surname ....

2. Christian Name/s ....

3. Date of birth [ ] [ ] [ ]

4. Male [ ] / Female [ ] (Please tick the appropriate block)

5. Do you belong to an environmental/conservation group?

   (Please tick the appropriate block) | Yes | No |

6. If your answer was Yes in the above question, please state which group (in or outside of school) you belong to.

   ....

7. Which of the following subjects do you take? (Please tick the appropriate block/s).

   Accountancy [ ]

   Biology [ ]

   Geography [ ]

   History [ ]

   Mathematics [ ]

   Physical Science [ ]

Environmental Concepts

Read the following statements carefully, and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

8. The term ecology refers to :

a) the study of the natural features of the earth's surface and man's response to them.

b) the study of the origin, structure and composition of the earth.

c) the study of the interrelationships between living organisms and their surroundings.

d) the study of the geographical distributions of organisms, their habitats and the historical and biological factors which produced them.

9. The term ecosystem refers to :

a) a type of system which is made up of a chain of subsystems, each having both a geographical location and a spatial vastness.

b) a system of whose structure nothing is known except that which can be deduced from its behaviour.

c) a system involving the interactions between a community of biotic organisms and their physical surroundings.

d) a type of system based on the existence of significant correlations between its morphological properties.

10. The term nature conservation means :

a) the exploitation of all natural resources.

b) the preservation of all natural resources.

c) the wise use of all natural resources.

d) the stockpiling of all natural resources.

11. R.J. Tanner's 'Spaceship Earth' concept refers to :

a) the fact that earth is part of the solar system and as such should be studied continuously.

b) the earth having limited resources and limited space, and as such creating the need for people to manage their numbers and the earth's resources carefully.

c) the fact that, if and when the earth's resources do 'run-out', they can be replenished as easily as refuelling a rocket.

d) the fact that many of the earth's problems could be solved by migration to other planets in the solar system.

12. The 'greenhouse effect' refers to :

a) the rise in temperature of the lower layers of the atmosphere, caused by an increase in carbon dioxide.

b) the rise in temperature of the lower layers of the atmosphere, caused by an increase in hydrogen oxide.

c) the rise in temperature of the lower layers of the atmosphere, caused by an increase in nitrogen oxide.

d) the rise in temperature of the lower layers of the atmosphere, caused by an increase in sulphur dioxide.

13. The term 'environment' refers to :

a) all the urban and suburban areas.

b) all the rural and indigenous vegetation areas.

c) all the nature and wilderness areas.

d) all the man-made and natural areas.

14. A food chain refers to :

a) the relationship between edible plants and energy input.

b) the transfer of energy through a series of plants and animals.

c) the particular energy output of edible plants and animals.

d) the amount of energy stored within plants and animals.

15. The term habitat refers to :

a) the natural habits of living organisms.

b) the natural state of non-living elements.

c) the natural domicile of living organisms.

d) the natural distribution of non-living elements.

16. The term 'radioactive half-life' refers to :

a) the time it takes for the atoms of a radioactive substance to increase its radioactivity by half.

b) the time it takes for the atoms of a radioactive substance to decay by half.

c) the time it takes for the atoms of a substance to become radioactive.

d) the time it takes for the atoms of a radioactive substance to become non-radioactive.

Environmental Knowledge

Read the following statements carefully and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

17. Radiation is :

    a) electromagnetic energy travelling at the same speed as the earth rotating on its axis.

    b) electromagnetic energy travelling at the same speed as that of the earth revolving around the sun.

    c) electromagnetic energy travelling at the speed of sound.

    d) electromagnetic energy travelling at the speed of light.

18. Plutonium is :

    a) a radio-active element.

    b) a radio-active component.

    c) a radio-active gas.

    d) a radio-active liquid.

19. Acid rain is :

    a) rainwater which turns into an acid when it comes into contact with sulphur and water in the atmosphere.

    b) the combination of sulphur dioxide, nitrogen oxides and water in the atmosphere which produces an acid rain.

    c) the combination of carbon dioxide and water in the atmosphere which produces an acid rain.

    d) the combination of nitrates in the atmosphere with water which causes an acid rain.

20. Nuclear fission refers to :

    a) a nuclear reaction in which an atomic nucleus is split, releasing energy.

    b) nuclear reaction in which an electron is split, releasing energy.

    c) a nuclear reaction in which a neutron is split, releasing energy.

    d) a nuclear reaction in which a proton is split, releasing energy.

21. Lise Meitner is a famous :

a) environmentalist

b) botanist

c) nuclear physicist

d) anti-nuclear activist

22. Pure rain has a pH level of :

a) 6.5

b) 4.8

c) 3.9

d) 5.7

23. The earth has a natural background radiation which is measured on the radiation scale at :

a) 3.1 rads/year

b) 2.7 rads/year

c) 0.1 rads/year

d) 1.2 rads/year

24. The nuclear accident at Three Mile Island (USA) happened in :

a) 1970

b) 1972

c) 1977

d) 1979

25. Rachel Carson's famous environmental classic is called :

a) Summer Showdown

b) Nuclear Winter

c) Autumn of Despair

d) Silent Spring

Environmental Attitudes (Attitudes towards the environment)

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice please circle the appropriate term listed underneath each statement, e.g. (Agree)

26. Nuclear power is dangerous.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

27. Nature reserves must be protected.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

28. Coal-fired power stations produce too much air pollution.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

29. Nuclear power is a valuable technological development.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

30. The continued use of coal in South Africa as an energy source is necessary.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

31. Preserving old buildings is a waste of tax-payers money.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

32. The conservation of historic urban areas is important.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

33. In environmental/conservation issues people are more important than animals.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

34. The exploding population is the greatest environmental problem facing the world.

Strongly disagree Disagree Uncertain Agree Strongly Agree

35. Minerals found in nature reserves should be exploited.

Strongly disagree Disagree Uncertain Agree Strongly Agree

36. Our growing electricity needs depends upon the use of nuclear power.

Strongly disagree Disagree Uncertain Agree Strongly Agree

37. The 'population explosion' only pertains to particular countries.

Strongly disagree Disagree Uncertain Agree Strongly Agree

38. The need for environmental conservation is not as important as the need for economic development.

Strongly disagree Disagree Uncertain Agree Strongly Agree

39. Recycling waste products is essential in today's world.

Strongly disagree Disagree Uncertain Agree Strongly Agree

40. Nuclear wastes cannot be safely stored.

Strongly disagree Disagree Uncertain Agree Strongly Agree

41. Whales must not be allowed to become extinct.

Strongly disagree Disagree Uncertain Agree Strongly Agree

42. South Africa needs nuclear weapons for defence purposes.

Strongly disagree Disagree Uncertain Agree Strongly Agree

43. Science and technology will solve all our problems.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

44. Pollution is an acceptable price to pay for progress.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

45. Our present lifestyle is the cause of the 'environmental crisis'.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

46. Littering is a serious environmental problem.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

47. Environmental problems will only be solved by the complete political restructuring of society.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

48. Alternative energy sources (eg solar power) must replace the coal, oil and nuclear options.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

Behavioural Intentions

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice please circle the appropriate term listed underneath each statement, e.g. (Agree)

49. I am considering joining an environmental/conservation group. (Even if I am already a member of one particular group)

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

50. School pupils cannot do anything against large organizations or government bodies.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

51. I intend reading and finding out more about environmental problems.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

52. School pupils cannot be expected to do anything about environmental issues such as the nuclear issue.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

53. School pupils should give up one Saturday a month to help pick up litter.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

54. I would be willing to give money towards an environmental/conservation project.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

55. I will encourage people not to support the building of a nuclear power station.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

56. I would be willing to take part in a demonstration against a company found guilty of polluting the environment.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

Evaluation of Simulation/Gaming as a Teaching Method

Read the item carefully. Choose the response which reflects your feeling most accurately. Having made your choice, please circle the appropriate term listed underneath the statement.

57. How often have you experienced simulation/gaming techniques in high school?

Never Very seldom Seldom often Very often

58. If you have experienced simulations/games, in which subjects were they "played"?

----

59. Do you feel that you learnt anything from the 'Coal or Nuclear' simulation/gaming technique?

i) Did it change or strengthen your attitudes towards environmental issues?

ii) Would you like to experience this approach (simulation/gaming) more often at school?

iii) Discuss what you feel are some of the positive or negative points about the 'Coal or Nuclear' simulation/gaming technique.

APPENDIX 8(b)

SECOND QUESTIONNAIRE

UNIVERSITY OF CAPE TOWN

ENVIRONMENTAL EDUCATION HIGH SCHOOL PUPIL QUESTIONNAIRE

The purpose of this questionnaire is to gain information about high school pupils' knowledge and attitudes about environmental education. When answering questions please reflect your own feelings and not what you perceive to be the correct answer. Your responses will not be scored in any way, and are only for the use of the researcher. The questionnaire will be kept strictly private and confidential.

Thank you for your co-operation.

PERSONAL DATA (Please fill in the required information)

1. Surname ....

2. Christian Name/s ....

3. Date of birth [ ][ ][ ]

4. Male [ ] Female [ ] (Please tick the appropriate block)

5. Do you belong to an environmental/conservation group?

   (Please tick the appropriate block) | Yes | No |

6. If your answer was Yes in the above question, please state which group (in or outside of school) you belong to.

   ....

7. Which of the following subjects do you take? (Please tick the appropriate block/s).

   Accountancy [ ]

   Biology [ ]

   Geography [ ]

   History [ ]

   Mathematics [ ]

   Physical Science [ ]

Environmental Concepts

Read the following statements carefully, and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

8. The term ecology refers to :

a) the study of the natural features of the earth's surface and man's response to them.

b) the study of the origin, structure and composition of the earth.

c) the study of the interrelationships between living organisms and their surroundings.

d) the study of the geographical distributions of organisms, their habitats and the historical and biological factors which produced them.

9. The term ecosystem refers to :

a) a type of system which is made up of a chain of subsystems, each having both a geographical location and a spatial vastness.

b) a system of whose structure nothing is known except that which can be deduced from its behaviour.

c) a system involving the interactions between a community of biotic organisms and their physical surroundings.

d) a type of system based on the existence of significant correlations between its morphological properties.

10. The term nature conservation means :

a) the exploitation of all natural resources.

b) the preservation of all natural resources.

c) the wise use of all natural resources.

d) the stockpiling of all natural resources.

11. R.J. Tanner's 'Spaceship Earth' concept refers to :

a) the fact that earth is part of the solar system and as such should be studied continuously.

b) the earth having limited resources and limited space, and as such creating the need for people to manage their numbers and the earth's resources carefully.

c) the fact that, if and when the earth's resources do 'run-out', they can be replenished as easily as refuelling a rocket.

d) the fact that many of the earth's problems could be solved by migration to other planets in the solar system.

12. The 'greenhouse effect' refers to :

a) the rise in temperature of the lower layers of the atmosphere, caused by an increase in carbon dioxide.

b) the rise in temperature of the lower layers of the atmosphere, caused by an increase in hydrogen oxide.

c) the rise in temperature of the lower layers of the atmosphere, caused by an increase in nitrogen oxide.

d) the rise in temperature of the lower layers of the atmosphere, caused by an increase in sulphur dioxide.

13. The term 'environment' refers to :

a) all the urban and suburban areas.

b) all the rural and indigenous vegetation areas.

c) all the nature and wilderness areas.

d) all the man-made and natural areas.

14. A food chain refers to :

a) the relationship between edible plants and energy input.

b) the transfer of energy through a series of plants and animals.

c) the particular energy output of edible plants and animals.

d) the amount of energy stored within plants and animals.

15. The term habitat refers to :

a) the natural habits of living organisms.

b) the natural state of non-living elements.

c) the natural domicile of living organisms.

d) the natural distribution of non-living elements.

16. The term 'radioactive half-life' refers to :

a) the time it takes for the atoms of a radioactive substance to increase its radioactivity by half.

b) the time it takes for the atoms of a radioactive substance to decay by half.

c) the time it takes for the atoms of a substance to become radioactive.

d) the time it takes for the atoms of a radioactive substance to become non-radioactive.

Environmental Knowledge

Read the following statements carefully and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

17. Radiation is :

    a) electromagnetic energy travelling at the same speed as the earth rotating on its axis.

    b) electromagnetic energy travelling at the same speed as that of the earth revolving around the sun.

    c) electromagnetic energy travelling at the speed of sound.

    d) electromagnetic energy travelling at the speed of light.

18. Plutonium is :

    a) a radio-active element.

    b) a radio-active component.

    c) a radio-active gas.

    d) a radio-active liquid.

19. Acid rain is :

    a) rainwater which turns into an acid when it comes into contact with sulphur and water in the atmosphere.

    b) the combination of sulphur dioxide, nitrogen oxides and water in the atmosphere which produces an acid rain.

    c) the combination of carbon dioxide and water in the atmosphere which produces an acid rain.

    d) the combination of nitrates in the atmosphere with water which causes an acid rain.

20. Nuclear fission refers to :

    a) a nuclear reaction in which an atomic nucleus is split, releasing energy.

    b) nuclear reaction in which an electron is split, releasing energy.

    c) a nuclear reaction in which a neutron is split, releasing energy.

    d) a nuclear reaction in which a proton is split, releasing energy.

21. Lise Meitner is a famous :

a) environmentalist

b) botanist

c) nuclear physicist

d) anti-nuclear activist

22. Pure rain has a pH level of :

a) 6.5

b) 4.8

c) 3.9

d) 5.7

23. The earth has a natural background radiation which is measured on the radiation scale at :

a) 3.1 rads/year

b) 2.7 rads/year

c) 0.1 rads/year

d) 1.2 rads/year

24. The nuclear accident at Three Mile Island (USA) happened in :

a) 1970

b) 1972

c) 1977

d) 1979

25. Rachel Carson's famous environmental classic is called :

a) Summer Showdown

b) Nuclear Winter

c) Autumn of Despair

d) Silent Spring

<u>Environmental Attitudes</u> (Attitudes towards the environment)

Read each item carefully. Choose the response which <u>reflects your feeling most accurately</u>. Having made your choice please circle the appropriate term listed underneath each statement, e.g. (Agree)

26. Nuclear power is dangerous.

Strongly disagree Disagree Uncertain Agree Strongly Agree

27. Nature reserves must be protected.

Strongly disagree Disagree Uncertain Agree Strongly Agree

28. Coal-fired power stations produce too much air pollution.

Strongly disagree Disagree Uncertain Agree Strongly Agree

29. Nuclear power is a valuable technological development.

Strongly disagree Disagree Uncertain Agree Strongly Agree

30. The continued use of coal in South Africa as an energy source is necessary.

Strongly disagree Disagree Uncertain Agree Strongly Agree

31. Preserving old buildings is a waste of tax-payers money.

Strongly disagree Disagree Uncertain Agree Strongly Agree

32. The conservation of historic urban areas is important.

Strongly disagree Disagree Uncertain Agree Strongly Agree

33. In environmental/conservation issues people are more important than animals.

Strongly disagree Disagree Uncertain Agree Strongly Agree

34. The exploding population is the greatest environmental problem facing the world.

Strongly disagree Disagree Uncertain Agree Strongly Agree

35. Minerals found in nature reserves should be exploited.

Strongly disagree Disagree Uncertain Agree Strongly Agree

36. Our growing electricity needs depends upon the use of nuclear power.

Strongly disagree Disagree Uncertain Agree Strongly Agree

37. The 'population explosion' only pertains to particular countries.

Strongly disagree Disagree Uncertain Agree Strongly Agree

38. The need for environmental conservation is not as important as the need for economic development.

Strongly disagree Disagree Uncertain Agree Strongly Agree

39. Recycling waste products is essential in today's world.

Strongly disagree Disagree Uncertain Agree Strongly Agree

40. Nuclear wastes cannot be safely stored.

Strongly disagree Disagree Uncertain Agree Strongly Agree

41. Whales must not be allowed to become extinct.

Strongly disagree Disagree Uncertain Agree Strongly Agree

42. South Africa needs nuclear weapons for defence purposes.

Strongly disagree Disagree Uncertain Agree Strongly Agree

43. Science and technology will solve all our problems.

Strongly disagree Disagree Uncertain Agree Strongly Agree

44. Pollution is an acceptable price to pay for progress.

Strongly disagree Disagree Uncertain Agree Strongly Agree

45. Our present lifestyle is the cause of the 'environmental crisis'.

Strongly disagree Disagree Uncertain Agree Strongly Agree

46. Littering is a serious environmental problem.

Strongly disagree Disagree Uncertain Agree Strongly Agree

47. Environmental problems will only be solved by the complete political restructuring of society.

Strongly disagree Disagree Uncertain Agree Strongly Agree

48. Alternative energy sources (eg solar power) must replace the coal, oil and nuclear options.

Strongly disagree Disagree Uncertain Agree Strongly Agree

Behavioural Intentions

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice please circle the appropriate term listed underneath each statement, e.g. Agree

49. I am considering joining an environmental/conservation group. (Even if I am already a member of one particular group)

Strongly disagree Disagree Uncertain Agree Strongly Agree

50. School pupils cannot do anything against large organizations or government bodies.

Strongly disagree Disagree Uncertain Agree Strongly Agree

51. I intend reading and finding out more about environmental problems.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

52. School pupils cannot be expected to do anything about environmental issues such as the nuclear issue.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

53. School pupils should give up one Saturday a month to help pick up litter.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

54. I would be willing to give money towards an environmental/conservation project.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

55. I will encourage people not to support the building of a nuclear power station.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

56. I would be willing to take part in a demonstration against a company found guilty of polluting the environment.

Strongly disagree   Disagree   Uncertain   Agree   Strongly Agree

APPENDIX 8(c)

FOR OFFICE USE ONLY

THIRD QUESTIONNAIRE

UNIVERSITY OF CAPE TOWN

ENVIRONMENTAL EDUCATION HIGH SCHOOL PUPIL QUESTIONNAIRE

The purpose of this questionnaire is to gain information about high school pupils' knowledge and attitudes about environmental education. When answering questions please reflect your own feelings and not what you perceive to be the correct answer. Your responses will not be scored in any way, and are only for the use of the researcher. The questionnaire will be kept strictly private and confidential.

Thank you for your co-operation. 1.

PERSONAL DATA (Please fill in the required information)

1. Surname ....

2. Christian Name/s .... 6.

3. Date of birth [| |] 10.

4. Male [ ] Female [ ] (Please tick the appropriate block)

5. Do you belong to an environmental/conservation group?

   (Please tick the appropriate block) [Yes | No]

6. If your answer was Yes in the above question, please state which group (in or outside of school) you belong to.

   ....

7. Which of the following subjects do you take? (Please tick the appropriate block/s).

   Accountancy [ ]

   Biology [ ]

   Geography [ ]

   History [ ]

   Mathematics [ ]

   Physical Science [ ] 18.

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Environmental Concepts

Read the following statements carefully, and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

8. The term ecology refers to :

   a) the study of the natural features of the earth's surface and man's response to them.

   b) the study of the origin, structure and composition of the earth.

   c) the study of the interrelationships between living organisms and their surroundings. 19.

   d) the study of the geographical distributions of organisms, their habitats and the historical and biological factors which produced them.

9. The term ecosystem refers to :

   a) a type of system which is made up of a chain of subsystems, each having both a geographical location and a spatial vastness.

   b) a system of whose structure nothing is known except that which can be deduced from its behaviour.

   c) a system involving the interactions between a community of biotic organisms and their physical surroundings.

   d) a type of system based on the existence of significant correlations between its morphological properties.

10. The term nature conservation means :

    a) the exploitation of all natural resources.

    b) the preservation of all natural resources.

    c) the wise use of all natural resources.

    d) the stockpiling of all natural resources.

11. R.J. Tanner's 'Spaceship Earth' concept refers to :

    a) the fact that earth is part of the solar system and as such should be studied continuously.

    b) the earth having limited resources and limited space, and as such creating the need for people to manage their numbers and the earth's resources carefully.

    c) the fact that, if and when the earth's resources do 'run-out', they can be replenished as easily as refuelling a rocket. 22.

    d) the fact that many of the earth's problems could be solved by migration to other planets in the solar system.

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12. The 'greenhouse effect' refers to :

a) the rise in temperature of the lower layers of the atmosphere, caused by an increase in carbon dioxide.

b) the rise in temperature of the lower layers of the atmosphere, caused by an increase in hydrogen oxide.

c) the rise in temperature of the lower layers of the atmosphere, caused by an increase in nitrogen oxide.

d) the rise in temperature of the lower layers of the atmosphere, caused by an increase in sulphur dioxide.

23.

13. The term 'environment' refers to :

a) all the urban and suburban areas.

b) all the rural and indigenous vegetation areas.

c) all the nature and wilderness areas.

d) all the man-made and natural areas.

14. A food chain refers to :

a) the relationship between edible plants and energy input.

b) the transfer of energy through a series of plants and animals.

c) the particular energy output of edible plants and animals.

d) the amount of energy stored within plants and animals.

15. The term habitat refers to :

a) the natural habits of living organisms.

b) the natural state of non-living elements.

c) the natural domicile of living organisms.

d) the natural distribution of non-living elements.

16. The term 'radioactive half-life' refers to :

a) the time it takes for the atoms of a radioactive substance to increase its radioactivity by half.

b) the time it takes for the atoms of a radioactive substance to decay by half.

c) the time it takes for the atoms of a substance to become radioactive.

d) the time it takes for the atoms of a radioactive substance to become non-radioactive.

27.

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Environmental Knowledge

Read the following statements carefully and then choose the one you feel is correct by circling the appropriate item letter, e.g. (c).

17. Radiation is :

a) electromagnetic energy travelling at the same speed as the earth rotating on its axis.

b) electromagnetic energy travelling at the same speed as that of the earth revolving around the sun.

c) electromagnetic energy travelling at the speed of sound.

d) electromagnetic energy travelling at the speed of light.

28.

18. Plutonium is :

a) a radio-active element.

b) a radio-active component.

c) a radio-active gas.

d) a radio-active liquid.

19. Acid rain is :

a) rainwater which turns into an acid when it comes into contact with sulphur and water in the atmosphere.

b) the combination of sulphur dioxide, nitrogen oxides and water in the atmosphere which produces an acid rain.

c) the combination of carbon dioxide and water in the atmosphere which produces an acid rain.

d) the combination of nitrates in the atmosphere with water which causes an acid rain.

20. Nuclear fission refers to :

a) a nuclear reaction in which an atomic nucleus is split, releasing energy.

b) nuclear reaction in which an electron is split, releasing energy.

c) a nuclear reaction in which a neutron is split, releasing energy.

d) a nuclear reaction in which a proton is split, releasing energy.

31.

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21. Lise Meitner is a famous :

a) environmentalist

b) botanist

c) nuclear physicist

d) anti-nuclear activist

32.

22. Pure rain has a pH level of :

a) 6.5

b) 4.8

c) 3.9

d) 5.7

23. The earth has a natural background radiation which is measured on the radiation scale at :

a) 3.1 rads/year

b) 2.7 rads/year

c) 0.1 rads/year

d) 1.2 rads/year

24. The nuclear accident at Three Mile Island (USA) happened in :

a) 1970

b) 1972

c) 1977

d) 1979

25. Rachel Carson's famous environmental classic is called :

a) Summer Showdown

b) Nuclear Winter

c) Autumn of Despair

d) Silent Spring

36.

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Environmental Attitudes (Attitudes towards the environment)

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice please circle the appropriate term listed underneath each statement, e.g. (Agree)

26. Nuclear power is dangerous.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 37.

27. Nature reserves must be protected.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

28. Coal-fired power stations produce too much air pollution.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

29. Nuclear power is a valuable technological development.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

30. The continued use of coal in South Africa as an energy source is necessary.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

31. Preserving old buildings is a waste of tax-payers money.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

32. The conservation of historic urban areas is important.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

33. In environmental/conservation issues people are more important than animals.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 44

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34. The exploding population is the greatest environmental problem facing the world.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 45.

35. Minerals found in nature reserves should be exploited.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

36. Our growing electricity needs depends upon the use of nuclear power.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

37. The 'population explosion' only pertains to particular countries.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

38. The need for environmental conservation is not as important as the need for economic development.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

39. Recycling waste products is essential in today's world.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

40. Nuclear wastes cannot be safely stored.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

41. Whales must not be allowed to become extinct.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

42. South Africa needs nuclear weapons for defence purposes.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 53.

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43. Science and technology will solve all our problems.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 54.

44. Pollution is an acceptable price to pay for progress.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

45. Our present lifestyle is the cause of the 'environmental crisis'.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

46. Littering is a serious environmental problem.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

47. Environmental problems will only be solved by the complete political restructuring of society.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

48. Alternative energy sources (eg solar power) must replace the coal, oil and nuclear options.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

Behavioural Intentions

Read each item carefully. Choose the response which reflects your feeling most accurately. Having made your choice please circle the appropriate term listed underneath each statement, e.g. (Agree)

49. I am considering joining an environmental/conservation group. (Even if I am already a member of one particular group)

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

50. School pupils cannot do anything against large organizations or government bodies.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 61.

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51. I intend reading and finding out more about environmental problems.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 62.

52. School pupils cannot be expected to do anything about environmental issues such as the nuclear issue.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

53. School pupils should give up one Saturday a month to help pick up litter.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

54. I would be willing to give money towards an environmental/conservation project.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

55. I will encourage people not to support the building of a nuclear power station.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐

56. I would be willing to take part in a demonstration against a company found guilty of polluting the environment.

Strongly disagree Disagree Uncertain Agree Strongly Agree ☐ 67.

APPENDIX 9

LETTER OF PERMISSION FROM THE CAPE EDUCATION DEPARTMENT

KAAPLANDSE ONDERWYSDEPARTEMENT
PROVINSIALE GEBOU, WAALSTRAAT,
POSBUS 13, KAAPSTAD, 8000

CAPE EDUCATION DEPARTMENT
PROVINCIAL BUILDING, WALE STREET
P.O. BOX 13, CAPE TOWN, 8000

TELEKS / TELEX 522368
TELEGRAM EDUCATION
TELEFOON / TELEPHONE 45-9333
NAVRAE / ENQUIRIES D.A. Norton
VERWYSING / REFERENCE L.15/73/7
DATUM / DATE 26 June 1987

Mr J Joyce
E41 Edingight
Queen Road
RONDEBOSCH
7700

SIMULATION/GAMING: A TEACHING TECHNIQUE FOR ENVIRONMENTAL EDUCATION: M. PHIL. THESIS

1. With reference to your letter dated 24 June 1987, the Department wishes to inform you of the following:

2. Your application is given conditional approval. The conditions are:

2.1 No school/pupil may be identifiable in any way in your research report.

2.2 All arrangements in connection with your project must be undertaken by yourself.

2.3 No research or data collection may be carried out involving schools during the fourth term.

2.4 No principal/teacher/school is under any obligation to provide the information required, or to co-operate in the research in any other way especially as you are asking for 6 periods of pupil time.

2.5 You will be required to discuss your project personally with each of the principals concerned, and only if an arrangement satisfactory to the principal in consultation with the relevant staff can be reached are you to conduct your research in the school concerned.

2.6 The conditions 2.1 to 2.5 above must be quoted in full when you approach the principals of the schools.

2.7 A copy of your applciation to principals of schools in which conditions 2.1 to 2.5 are to be given, must be forwarded to the Head: Research Section, Cape Education Department before they are approached for their cooperation.

2.8 A synopsis (± 3 pages) of the contents, findings and recommendations in respect of your project must be placed at the disposal of the Department.

2.9 In addition to the synopsis mentioned in par. 2.8 you are requested to submit a copy of yout completed thesis to each of the following:

- The Education Library, and

- The Research Section
  Cape Education Department
  P.O. Box 13
  CAPE TOWN
  8000

3. The Department wishes you every success in your studies.

Yours faithfully

Signed by candidate
Signature Removed

EDUCATION

APPENDIX 10

COMPUTER RUN STREAMS

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IF (CNC1 NE 3) THEN (CG1 = 0).
IF (CNC2 EQ 3) THEN (CG2 = 1. CG10 = CG10 + 1.).
IF (CNC2 NE 3) THEN (CG2 = 0).
IF (CNC3 EQ 3) THEN (CG3 = 1. CG10 = CG10 + 1.).
IF (CNC3 NE 3) THEN (CG3 = 0).
IF (CNC4 EQ 2) THEN (CG4 = 1. CG10 = CG10 + 1.).
IF (CNC4 NE 2) THEN (CG4 = 0).
IF (CNC5 EQ 1) THEN (CG5 = 1. CG10 = CG10 + 1.).
IF (CNC5 NE 1) THEN (CG5 = 0).
IF (CNC6 EQ 4) THEN (CG6 = 1. CG10 = CG10 + 1.).
IF (CNC6 NE 4) THEN (CG6 = 0).
IF (CNC7 EQ 2) THEN (CG7 = 1. CG10 = CG10 + 1.).
IF (CNC7 NE 2) THEN (CG7 = 0).
IF (CNC8 EQ 3) THEN (CG8 = 1. CG10 = CG10 + 1.).
IF (CNC8 NE 3) THEN (CG8 = 0).
IF (CNC9 EQ 2) THEN (CG9 = 1. CG10 = CG10 + 1.).
IF (CNC9 NE 2) THEN (CG9 = 0).
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IF (KNW1 NE 4) THEN (KG1 = 0).
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IF (KNW2 NE 1) THEN (KG2 = 0).
IF (KNW3 EQ 2) THEN (KG3 = 1. KG10 = KG10 + 1.).
IF (KNW3 NE 2) THEN (KG3 = 0).
IF (KNW4 EQ 1) THEN (KG4 = 1. KG10 = KG10 + 1.).
IF (KNW4 NE 1) THEN (KG4 = 0).
IF (KNW5 EQ 3) THEN (KG5 = 1. KG10 = KG10 + 1.).
IF (KNW5 NE 3) THEN (KG5 = 0).
IF (KNW6 EQ 4) THEN (KG6 = 1. KG10 = KG10 + 1.).
IF (KNW6 NE 4) THEN (KG6 = 0).
IF (KNW7 EQ 3) THEN (KG7 = 1. KG10 = KG10 + 1.).
IF (KNW7 NE 3) THEN (KG7 = 0).
IF (KNW8 EQ 4) THEN (KG8 = 1. KG10 = KG10 + 1.).
IF (KNW8 NE 4) THEN (KG8 = 0).
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IF (KNW9 NE 4) THEN (KG9 = 0).
IF (AT1 LE 3) THEN (AG1 = 0).
IF (AT1 GT 3) THEN (AG1 = 1. AG33 = AG33 + 1.).
IF (AT2 LE 3) THEN (AG2 = 0).
IF (AT2 GT 3) THEN (AG2 = 1. AG33 = AG33 + 1.).
IF (AT3 LE 3) THEN (AG3 = 0).
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PARAGON

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IF (AT3 GT 3) THEN (AG3 = 1. AG33 = AG33 + 1.).
IF (AT4 LE 3) THEN (AG4 = 1. AG33 = AG33 + 1.).
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IF (AT5 GT 2) THEN (AG5 = 1. AG33 = AG33 + 1.).
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IF (AT6 GT 2) THEN (AG6 = 0).
IF (AT7 LE 2) THEN (AG7 = 0).
IF (AT7 GT 2) THEN (AG7 = 1. AG33 = AG33 + 1.).
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IF (AT8 GT 2) THEN (AG8 = 1. AG33 = AG33 + 1.).
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IF (AT10 LE 3) THEN (AG10 = 1. AG33 = AG33 + 1.).
IF (AT10 GT 3) THEN (AG10 = 0).
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IF (AT12 LE 2) THEN (AG12 = 1. AG33 = AG33 + 1.).
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IF (AT24 GT 3) THEN (AG24 = 1. AG34 = AG34 + 1.).
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IF (C2CNC1 NE 3) THEN (C2CG1 = 0).
IF (C2CNC2 EQ 3) THEN (C2CG2 = 1. C2CG10 = C2CG10 + 1.).
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IF (C2CNC5 NE 1) THEN (C2CG5 = 0).
IF (C2CNC6 EQ 4) THEN (C2CG6 = 1. C2CG10 = C2CG10 + 1.).
IF (C2CNC6 NE 4) THEN (C2CG6 = 0).
IF (C2CNC7 EQ 2) THEN (C2CG7 = 1. C2CG10 = C2CG10 + 1.).
IF (C2CNC7 NE 2) THEN (C2CG7 = 0).
IF (C2CNC8 EQ 3) THEN (C2CG8 = 1. C2CG10 = C2CG10 + 1.).
IF (C2CNC8 NE 3) THEN (C2CG8 = 0).
IF (C2CNC9 EQ 2) THEN (C2CG9 = 1. C2CG10 = C2CG10 + 1.).
IF (C2CNC9 NE 2) THEN (C2CG9 = 0).
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IF (K2KNW1 NE 4) THEN (K2KG1 = 0).
IF (K2KNW2 EQ 1) THEN (K2KG2 = 1. K2KG10 = K2KG10 + 1.).
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IF (K2KNW5 NE 3) THEN (K2KG5 = 0).
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IF (K2KNW6 NE 4) THEN (K2KG6 = 0).
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IF (K2KNW7 NE 3) THEN (K2KG7 = 0).
IF (K2KNW8 EQ 4) THEN (K2KG8 = 1. K2KG10 = K2KG10 + 1.).
IF (K2KNW8 NE 4) THEN (K2KG8 = 0).
IF (K2KNW9 EQ 4) THEN (K2KG9 = 1. K2KG10 = K2KG10 + 1.).
IF (K2KNW9 NE 4) THEN (K2KG9 = 0).
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IF (A2AT1 GT 3) THEN (A2AG1 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT2 LE 3) THEN (A2AG2 = 0).
IF (A2AT2 GT 3) THEN (A2AG2 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT3 LE 3) THEN (A2AG3 = 0).
IF (A2AT3 GT 3) THEN (A2AG3 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT4 LE 3) THEN (A2AG4 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT4 GT 3) THEN (A2AG4 = 0).
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IF (A2AT6 LE 2) THEN (A2AG6 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT6 GT 2) THEN (A2AG6 = 0).
IF (A2AT7 LE 2) THEN (A2AG7 = 0).
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IF (A2AT9 LE 3) THEN (A2AG9 = 0).
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IF (A2AT10 LE 3) THEN (A2AG10 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT10 GT 3) THEN (A2AG10 = 0).
IF (A2AT11 LE 2) THEN (A2AG11 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT11 GT 2) THEN (A2AG11 = 0).
IF (A2AT12 LE 2) THEN (A2AG12 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT12 GT 2) THEN (A2AG12 = 0).
IF (A2AT13 LE 2) THEN (A2AG13 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT13 GT 2) THEN (A2AG13 = 0).
IF (A2AT14 LE 3) THEN (A2AG14 = 0).
IF (A2AT14 GT 3) THEN (A2AG14 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT15 LE 3) THEN (A2AG15 = 0).
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IF (A2AT15 GT 3) THEN (A2AG15 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT16 LE 3) THEN (A2AG16 = 0).
IF (A2AT16 GT 3) THEN (A2AG16 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT17 LE 2) THEN (A2AG17 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT17 GT 2) THEN (A2AG17 = 0).
IF (A2AT18 LE 3) THEN (A2AG18 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT18 GT 3) THEN (A2AG18 = 0).
IF (A2AT19 LE 2) THEN (A2AG19 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT19 GT 2) THEN (A2AG19 = 0).
IF (A2AT20 LE 3) THEN (A2AG20 = 0).
IF (A2AT20 GT 3) THEN (A2AG20 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT21 LE 3) THEN (A2AG21 = 0).
IF (A2AT21 GT 3) THEN (A2AG21 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT22 LE 3) THEN (A2AG22 = 0).
IF (A2AT22 GT 3) THEN (A2AG22 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT23 LE 3) THEN (A2AG23 = 0).
IF (A2AT23 GT 3) THEN (A2AG23 = 1. A2AG33 = A2AG33 + 1.).
IF (A2AT24 LE 3) THEN (A2AG24 = 0).
IF (A2AT24 GT 3) THEN (A2AG24 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT25 LE 2) THEN (A2AG25 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT25 GT 2) THEN (A2AG25 = 0).
IF (A2AT26 LE 3) THEN (A2AG26 = 0).
IF (A2AT26 GT 3) THEN (A2AG26 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT27 LE 2) THEN (A2AG27 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT27 GT 2) THEN (A2AG27 = 0).
IF (A2AT28 LE 3) THEN (A2AG28 = 0).
IF (A2AT28 GT 3) THEN (A2AG28 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT29 LE 3) THEN (A2AG29 = 0).
IF (A2AT29 GT 3) THEN (A2AG29 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT30 LE 3) THEN (A2AG30 = 0).
IF (A2AT30 GT 3) THEN (A2AG30 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT31 LE 3) THEN (A2AG31 = 0).
IF (A2AT31 GT 3) THEN (A2AG31 = 1. A2AG34 = A2AG34 + 1.).
IF (A2AT32 LE 3) THEN (A2AG32 = 0).
IF (A2AT32 GT 3) THEN (A2AG32 = 1. A2AG34 = A2AG34 + 1.).
IF (C3CNC1 EQ 3) THEN (C3CG1 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC1 NE 3) THEN (C3CG1 = 0).
V3SCHOOL = V2SCHOOL.
V3SEX = V2SEX.
V3GRP = V2GRP.
V3SUB1 = V2SUB1.
V3SUB2 = V2SUB2.
V3SUB3 = V2SUB3.
V3SUB4 = V2SUB4.
V3SUB5 = V2SUB5.
V3SUB6 = V2SUB6.
IF (C3CNC3 EQ 3) THEN (C3CG2 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC3 NE 3) THEN (C3CG2 = 0).
IF (C3CNC3 EQ 3) THEN (C3CG3 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC3 NE 3) THEN (C3CG3 = 0).
IF (C3CNC4 EQ 2) THEN (C3CG4 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC4 NE 2) THEN (C3CG4 = 0).
IF (C3CNC5 EQ 1) THEN (C3CG5 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC5 NE 1) THEN (C3CG5 = 0).
IF (C3CNC6 EQ 4) THEN (C3CG6 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC6 NE 4) THEN (C3CG6 = 0).
IF (C3CNC7 EQ 2) THEN (C3CG7 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC7 NE 2) THEN (C3CG7 = 0).
IF (C3CNC8 EQ 3) THEN (C3CG8 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC8 NE 3) THEN (C3CG8 = 0).
IF (C3CNC9 EQ 2) THEN (C3CG9 = 1. C3CG10 = C3CG10 + 1.).
IF (C3CNC9 NE 2) THEN (C3CG9 = 0).
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IF (K3KNW1 EQ 4) THEN (K3KG1 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW1 NE 4) THEN (K3KG1 = 0).
IF (K3KNW2 EQ 1) THEN (K3KG2 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW2 NE 1) THEN (K3KG2 = 0).
IF (K3KNW3 EQ 2) THEN (K3KG3 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW3 NE 2) THEN (K3KG3 = 0).
IF (K3KNW4 EQ 1) THEN (K3KG4 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW4 NE 1) THEN (K3KG4 = 0).
IF (K3KNW5 EQ 3) THEN (K3KG5 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW5 NE 3) THEN (K3KG5 = 0).
IF (K3KNW6 EQ 4) THEN (K3KG6 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW6 NE 4) THEN (K3KG6 = 0).
IF (K3KNW7 EQ 3) THEN (K3KG7 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW7 NE 3) THEN (K3KG7 = 0).
IF (K3KNW8 EQ 4) THEN (K3KG8 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW8 NE 4) THEN (K3KG8 = 0).
IF (K3KNW9 EQ 4) THEN (K3KG9 = 1. K3KG10 = K3KG10 + 1.).
IF (K3KNW9 NE 4) THEN (K3KG9 = 0).
IF (A3AT1 LE 3) THEN (A3AG1 = 0).
IF (A3AT1 GT 3) THEN (A3AG1 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT2 LE 3) THEN (A3AG2 = 0).
IF (A3AT2 GT 3) THEN (A3AG2 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT3 LE 3) THEN (A3AG3 = 0).
IF (A3AT3 GT 3) THEN (A3AG3 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT4 LE 3) THEN (A3AG4 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT4 GT 3) THEN (A3AG4 = 0).
IF (A3AT5 LE 2) THEN (A3AG5 = 0).
IF (A3AT5 GT 2) THEN (A3AG5 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT6 LE 2) THEN (A3AG6 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT6 GT 2) THEN (A3AG6 = 0).
IF (A3AT7 LE 2) THEN (A3AG7 = 0).
IF (A3AT7 GT 2) THEN (A3AG7 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT8 LE 2) THEN (A3AG8 = 0).
IF (A3AT8 GT 2) THEN (A3AG8 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT9 LE 3) THEN (A3AG9 = 0).
IF (A3AT9 GT 3) THEN (A3AG9 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT10 LE 3) THEN (A3AG10 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT10 GT 3) THEN (A3AG10 = 0).
IF (A3AT11 LE 2) THEN (A3AG11 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT11 GT 2) THEN (A3AG11 = 0).
IF (A3AT12 LE 2) THEN (A3AG12 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT12 GT 2) THEN (A3AG12 = 0).
IF (A3AT13 LE 2) THEN (A3AG13 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT13 GT 2) THEN (A3AG13 = 0).
IF (A3AT14 LE 3) THEN (A3AG14 = 0).
IF (A3AT14 GT 3) THEN (A3AG14 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT15 LE 3) THEN (A3AG15 = 0).
IF (A3AT15 GT 3) THEN (A3AG15 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT16 LE 3) THEN (A3AG16 = 0).
IF (A3AT16 GT 3) THEN (A3AG16 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT17 LE 2) THEN (A3AG17 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT17 GT 2) THEN (A3AG17 = 0).
IF (A3AT18 LE 3) THEN (A3AG18 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT18 GT 3) THEN (A3AG18 = 0).
IF (A3AT19 LE 2) THEN (A3AG19 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT19 GT 2) THEN (A3AG19 = 0).
IF (A3AT20 LE 3) THEN (A3AG20 = 0).
IF (A3AT20 GT 3) THEN (A3AG20 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT21 LE 3) THEN (A3AG21 = 0).
IF (A3AT21 GT 3) THEN (A3AG21 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT22 LE 3) THEN (A3AG22 = 0).
IF (A3AT22 GT 3) THEN (A3AG22 = 1. A3AG33 = A3AG33 + 1.).
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IF (A3AT23 LE 3) THEN (A3AG23 = 0).
IF (A3AT23 GT 3) THEN (A3AG23 = 1. A3AG33 = A3AG33 + 1.).
IF (A3AT24 LE 3) THEN (A3AG24 = 0).
IF (A3AT24 GT 3) THEN (A3AG24 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT25 LE 2) THEN (A3AG25 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT25 GT 2) THEN (A3AG25 = 0).
IF (A3AT26 LE 3) THEN (A3AG26 = 0).
IF (A3AT26 GT 3) THEN (A3AG26 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT27 LE 2) THEN (A3AG27 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT27 GT 2) THEN (A3AG27 = 0).
IF (A3AT28 LE 3) THEN (A3AG28 = 0).
IF (A3AT28 GT 3) THEN (A3AG28 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT29 LE 3) THEN (A3AG29 = 0).
IF (A3AT29 GT 3) THEN (A3AG29 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT30 LE 3) THEN (A3AG30 = 0).
IF (A3AT30 GT 3) THEN (A3AG30 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT31 LE 3) THEN (A3AG31 = 0).
IF (A3AT31 GT 3) THEN (A3AG31 = 1. A3AG34 = A3AG34 + 1.).
IF (A3AT32 LE 3) THEN (A3AG32 = 0).
IF (A3AT32 GT 3) THEN (A3AG32 = 1. A3AG34 = A3AG34 + 1.).
D1C1 = C2CG1 - CG1 .
D1C2 = C2CG2 - CG2 .
D1C3 = C2CG3 - CG3 .
D1C4 = C2CG4 - CG4 .
D1C5 = C2CG5 - CG5 .
D1C6 = C2CG6 - CG6 .
D1C7 = C2CG7 - CG7 .
D1C8 = C2CG8 - CG8 .
D1C9 = C2CG9 - CG9 .
D1C10 = C2CG10 - CG10 .
D1K1 = K2KG1 - KG1 .
D1K2 = K2KG2 - KG2 .
D1K3 = K2KG3 - KG3 .
D1K4 = K2KG4 - KG4 .
D1K5 = K2KG5 - KG5 .
D1K6 = K2KG6 - KG6 .
D1K7 = K2KG7 - KG7 .
D1K8 = K2KG8 - KG8 .
D1K9 = K2KG9 - KG9 .
D1K10 = K2KG10 - KG10 .
D1A01 = A2AG1 - AG1 .
D1A02 = A2AG2 - AG2 .
D1A03 = A2AG3 - AG3 .
D1A04 = A2AG4 - AG4 .
D1A05 = A2AG5 - AG5 .
D1A06 = A2AG6 - AG6 .
D1A07 = A2AG7 - AG7 .
D1A08 = A2AG8 - AG8 .
D1A09 = A2AG9 - AG9 .
D1A10 = A2AG10 - AG10 .
D1A11 = A2AG11 - AG11 .
D1A12 = A2AG12 - AG12 .
D1A13 = A2AG13 - AG13 .
D1A14 = A2AG14 - AG14 .
D1A15 = A2AG15 - AG15 .
D1A16 = A2AG16 - AG16 .
D1A17 = A2AG17 - AG17 .
D1A18 = A2AG18 - AG18 .
D1A19 = A2AG19 - AG19 .
D1A20 = A2AG20 - AG20 .
D1A21 = A2AG21 - AG21 .
D1A22 = A2AG22 - AG22 .
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D1A23 = A2AG23 - AG23 .
D1A24 = A2AG24 - AG24 .
D1A25 = A2AG25 - AG25 .
D1A26 = A2AG26 - AG26 .
D1A27 = A2AG27 - AG27 .
D1A28 = A2AG28 - AG28 .
D1A29 = A2AG29 - AG29 .
D1A30 = A2AG30 - AG30 .
D1A31 = A2AG31 - AG31 .
D1A32 = A2AG32 - AG32 .
D1A33 = A2AG33 - AG33 .
D1A34 = A2AG34 - AG34 .
DC2C1 = C3CG1 - C2CG1 .
DC2C2 = C3CG2 - C2CG2 .
DC2C3 = C3CG3 - C2CG3 .
DC2C4 = C3CG4 - C2CG4 .
DC2C5 = C3CG5 - C2CG5 .
DC2C6 = C3CG6 - C2CG6 .
DC2C7 = C3CG7 - C2CG7 .
DC2C8 = C3CG8 - C2CG8 .
DC2C9 = C3CG9 - C2CG9 .
DC2C10 = C3CG1C - C2CG10 .
DK2K1 = K3KG1 - K2KG1 .
DK2K2 = K3KG2 - K2KG2 .
DK2K3 = K3KG3 - K2KG3 .
DK2K4 = K3KG4 - K2KG4 .
DK2K5 = K3KG5 - K2KG5 .
DK2K6 = K3KG6 - K2KG6 .
DK2K7 = K3KG7 - K2KG7 .
DK2K8 = K3KG8 - K2KG8 .
DK2K9 = K3KG9 - K2KG9 .
DK2K10 = K3KG1C - K2KG10 .
DA2A01 = A3AG1 - A2AG1 .
DA2A02 = A3AG2 - A2AG2 .
DA2A03 = A3AG3 - A2AG3 .
DA2A04 = A3AG4 - A2AG4 .
DA2A05 = A3AG5 - A2AG5 .
DA2A06 = A3AG6 - A2AG6 .
DA2A07 = A3AG7 - A2AG7 .
DA2A08 = A3AG8 - A2AG8 .
DA2A09 = A3AG9 - A2AG9 .
DA2A10 = A3AG10 - A2AG10 .
DA2A11 = A3AG11 - A2AG11 .
DA2A12 = A3AG12 - A2AG12 .
DA2A13 = A3AG13 - A2AG13 .
DA2A14 = A3AG14 - A2AG14 .
DA2A15 = A3AG15 - A2AG15 .
DA2A16 = A3AG16 - A2AG16 .
DA2A17 = A3AG17 - A2AG17 .
DA2A18 = A3AG18 - A2AG18 .
DA2A19 = A3AG19 - A2AG19 .
DA2A20 = A3AG20 - A2AG20 .
DA2A21 = A3AG21 - A2AG21 .
DA2A22 = A3AG22 - A2AG22 .
DA2A23 = A3AG23 - A2AG23 .
DA2A24 = A3AG24 - A2AG24 .
DA2A25 = A3AG25 - A2AG25 .
DA2A26 = A3AG26 - A2AG26 .
DA2A27 = A3AG27 - A2AG27 .
DA2A28 = A3AG28 - A2AG28 .
DA2A29 = A3AG29 - A2AG29 .
DA2A30 = A3AG30 - A2AG30 .
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DA2A31 = A3AG31 - A2AG31 .
DA2A32 = A3AG32 - A2AG32 .
DA2A33 = A3AG33 - A2AG33 .
DA2A34 = A3AG34 - A2AG34 .
DC3C1 = C3CG1 - CG1 .
DC3C2 = C3CG2 - CG2 .
DC3C3 = C3CG3 - CG3 .
DC3C4 = C3CG4 - CG4 .
DC3C5 = C3CG5 - CG5 .
DC3C6 = C3CG6 - CG6 .
DC3C7 = C3CG7 - CG7 .
DC3C8 = C3CG8 - CG8 .
DC3C9 = C3CG9 - CG9 .
DC3C10 = C3CG10 - CG10 .
DK3K1 = K3KG1 - KG1 .
DK3K2 = K3KG2 - KG2 .
DK3K3 = K3KG3 - KG3 .
DK3K4 = K3KG4 - KG4 .
DK3K5 = K3KG5 - KG5 .
DK3K6 = K3KG6 - KG6 .
DK3K7 = K3KG7 - KG7 .
DK3K8 = K3KG8 - KG8 .
DK3K9 = K3KG9 - KG9 .
DK3K10 = K3KG10 - KG10 .
DA3A01 = A3AG1 - AG1 .
DA3A02 = A3AG2 - AG2 .
DA3A03 = A3AG3 - AG3 .
DA3A04 = A3AG4 - AG4 .
DA3A05 = A3AG5 - AG5 .
DA3A06 = A3AG6 - AG6 .
DA3A07 = A3AG7 - AG7 .
DA3A08 = A3AG8 - AG8 .
DA3A09 = A3AG9 - AG9 .
DA3A10 = A3AG10 - AG10 .
DA3A11 = A3AG11 - AG11 .
DA3A12 = A3AG12 - AG12 .
DA3A13 = A3AG13 - AG13 .
DA3A14 = A3AG14 - AG14 .
DA3A15 = A3AG15 - AG15 .
DA3A16 = A3AG16 - AG16 .
DA3A17 = A3AG17 - AG17 .
DA3A18 = A3AG18 - AG18 .
DA3A19 = A3AG19 - AG19 .
DA3A20 = A3AG20 - AG20 .
DA3A21 = A3AG21 - AG21 .
DA3A22 = A3AG22 - AG22 .
DA3A23 = A3AG23 - AG23 .
DA3A24 = A3AG24 - AG24 .
DA3A25 = A3AG25 - AG25 .
DA3A26 = A3AG26 - AG26 .
DA3A27 = A3AG27 - AG27 .
DA3A28 = A3AG28 - AG28 .
DA3A29 = A3AG29 - AG29 .
DA3A30 = A3AG30 - AG30 .
DA3A31 = A3AG31 - AG31 .
DA3A32 = A3AG32 - AG32 .
DA3A33 = A3AG33 - AG33 .
DA3A34 = A3AG34 - AG34 .
/SAVE FILE=JOYCEDATA.CODE=BMD1. NEW.
/CATEGORY CUTPOINTS(238,292,346) ARE 5,7,9,11,13,15,17,19,21.
   CUTPOINTS(357,367,401,411,421,455,465,475,509) ARE -8,-6,-4,-2,
      CUTPOINTS(400,454,508) ARE -10,-7,-4,-2,1,3,6,9.
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/TABLE ROW ARE 1 TO 509.
       COL ARE 4,10,11,184,7,8,185.
       CROSS.
/PRINT PERC = COL,TCT.
/STATISTICS MINIMUM = 5.
            CHISQ.
            FISH.
/TABLE ROW ARE 1 TO 122, 1 TO 61, 186 TO 293, 186 TO 239,
                 348 TO 455, 348 TO 401.
       COL ARE 62 TO 183, 123 TO 183, 240 TO 347, 294 TO 347,
                 402 TO 509, 456 TO 509.
       PAIR.
/PRINT PERC = TOT.
/STAT  MIN = 5.
       MCNEMAR.
/END
@ADD,P STATS*202S.JOYDATA
/END
@FIN
```

APPENDIX 11

McNemar Chi-square Statistics
- for Table 7.3

		INTERVAL CAT 1	YES/NO 1	INTERVAL CAT 2	YES/NO 2	INTERVAL CAT 3	YES/NO 3
CONCEPTS	1	15.9	5.0				6.4
	2				72.1		72.1
	3						
	4	25.0	18.7	14.0			
	5				5.2		5.4
	6						
	7						
	8			14.9	8.3		
	9			11.5		17.0	10.2
KNOWLEDGE	1	17.7	10.0			18.4	5.9
	2	19.7	16.1				9.6
	3	33.7	27.2	20.7	18.6	13.7	
	4						
	5	15.5	10.9				6.6
	6	33.3	30.3	18.4	9.4	19.3	15.9
	7	44.5	41.7		5.3	23.8	15.8
	8	48.7	41.0	39.5	36.8		
	9	32.6	25.8			31.7	26.7
ATTITUDES	1						4.2
	2						
	3	34.1	19.6				10.3
	4	14.4					
	5	30.0	22.0		32.1		7.1
	6	25.4			13.5		23.5
	7				10.0		8.3
	8				8.1		7.0
	9						4.8
	10		9.0		8.1		
	11		9.3		24.1		5.5
	12	25.9	10.5		22.1		8.9
	13				25.1		16.3
	14						
	15		6.3				9.3
	16						
	17	21.3	10.0		22.5		8.3
	18	13.3			4.6		10.0
	19						
	20				6.2		4.2
	21						5.3
	22				5.7		5.2
	23	46.9	24.2				22.2
BEHAVIOURAL INTENTIONS	24				10.9		7.2
	25				12.6		7.5
	26		13.7				
	27	18.0	12.5		14.20		
	28	14.4	5.4				3.9
	29		5.4		8.3		
	30						
	31	14.3	8.3				
	32						
Concepts Knowledge Attitudes Behavioural Intent.							5.9

APPENDIX 12

p-values of McNemar chi-square
- for Table 7.3

		INTERVAL CAT (1)	YES/NO (1)	INTERVAL CAT (2)	YES/NO (2)	INTERVAL CAT (3)	YES/NO (3)
CONCEPTS	1	.015	.025				.011
	2				.000		.000
	3						
	4	.000	.000	.016			
	5				.022		.020
	6						
	7						
	8			.021	.004		
	9			.044	.001	.001	.001
KNOWLEDGE	1	.007	.002			.005	.015
	2	.003	.000				.001
	3	.000	.000	.002	.000	.033	
	4						
	5	.017	.001				.010
	6	.000	.000	.005	.002	.004	.000
	7	.000	.000		.021	.001	.000
	8	.000	.000	.000	.000		
	9	.000	.000			.000	.000
ATTITUDES	1						.041
	2						
	3	.000	.000				.001
	4	.040					
	5	.001	.000		.000		.008
	6	.003			.000		.000
	7				.002		.004
	8				.005		.008
	9						.028
	10		.003		.005		
	11		.002		.000		.019
	12	.002	.001		.000		.003
	13				.000		.000
	14						
	15		.012				.002
	16						
	17	.006	.002		.000		.004
	18	.038			.033		.002
	19				.013		.041
	20						.021
	21						
	22				.016		.022
	23	.000	.000				.000
BEHAVIOURAL INTENTIONS	24				.001		.007
	25				.000		.006
	26		.000				
	27	.021	.000		.000		
	28	.025	.020				.048
	29		.020		.004		
	30						
	31	.046	.004				
	32						
Concepts Knowledge Attitudes Behavioural Intent.							.015

APPENDIX 13

Mcnemar Chisquare Statistics
- for Table 7.5 (Gender)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1							8.60	6.25	
C	2			14.9	13.4				7.30	
O	3									
N	4									
C	5							6.25		
E	6				6.91					
P	7									
T	8									
S	9	11.6	4.28		6.31				11.3	8.56
K	1								6.29	
N	2	8.81	6.26					11.5		10.3
O	3									6.87
W	4							6.46		
L	5									
E	6									
D	7									
G	8			9.37	6.14		5.38			
E	9									
	1									
	2									
A	3	9.15								
	4	16.9	9.90		4.84	8.78	4.07	10.8		18.4
T	5	8.62	5.79			8.07	8.03			
	6	14.7	8.05	14.1					6.37	
T	7		8.75	12.0						
	8									
I	9			10.1						
	10									
T	11		9.84							
	12									
U	13									
	14							9.25		
D	15	13.9								
	16									
E	17	11.3	4.18							
	18									7.37
S	19									
	20									
	21									
	22									
	23	11.6	6.75					7.65		6.56
B I	24		6.59			8.92	6.07			
E N	25									
H T	26		5.92							
A E	27						5.45			
V N	28	22.2	10.9	22.3	16.7	8.31		6.93		
I T	29					10.2	9.68		11.2	6.11
O I	30	25.4	6.14	9.87	4.55					
U O	31									
R N	32									
A S										
L										
Concepts				7.26			7.97			
Knowledge							16.7			
Attitudes				7.29						
Behavioural Intent.				9.87			13.9			

APPENDIX 14

p-values associated with McNemar Statistics for Table 7.5 (Gender)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1							.014	.044	
C	2			.002	.000				.026	
O	3									
N	4									
C	5							.044		
E	6				.009					
P	7									
T	8									
S	9	.039	.009		.012				.004	.014
K	1								.043	
N	2	.012	.032					.003		.006
O	3									.032
W	4							.040		
L	5									
E	6									
D	7									
G	8			.025	.013		.020			
E	9									
	1									
	2									
A	3	.012								
	4	.002	.002		.028	.032	.047	.005		.000
T	5	.016	.071			.045	.005			
	6	.005	.005	.007					.041	
T	7		.035	.017						
	8									
I	9			.038						
	10									
T	11		.048							
	12									
U	13									
	14							.010		
D	15	.007								
	16									
E	17	.023	.041							
	18									.032
S	19									
	20									
	21									
	22									
	23	.021	.009					.022		.001
B I	24		.010			.030	.014			
E N	25									
H T	26		.015							
A E	27						.020			
V N	28	.000	.001	.000	.000	.040		.031		
I T	29					.017	.002		.004	.002
O I	30	.000	.013	.043	.033					
U O	31									
R N	32									
A S										
L										
Concepts				.030			.040			
Knowledge							.011			
Attitudes				.030						
Behavioural Intent.				.030			.045			

APPENDIX 15

McNemar Chisquare Statistics
- for Table 7.6 (BIO)

			TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
		1	13.9	11.5			10.8	7.54	7.55		
C		2	11.1	4.88	15.1	10.5	5.28			8.48	
O		3									
N		4									
C		5									
E		6									
P		7									
T		8									
S		9		6.93	13.3	12.3				6.55	
K		1				4.57					
N		2		4.51		7.27		6.52			
O		3									
W		4									
L		5									
E		6			12.4	4.79			6.53		
D		7			12.7	10.0				9.99	
G		8			11.7	8.67			7.68		
E		9	14.5	12.8							7.50
		1									
		2									
A		3									
		4									
T		5									
		6									
T		7									
		8							13.4		7.10
I		9									
		10									
T		11	8.53								
		12									
U		13	11.5								
		14		4.12							
D		15	18.1	16.2	8.42	5.02					
		16	7.06		5.66						
E		17									
		18									
S		19									
		20									
		21									
		22									
		23		4.65				6.93	6.70		6.62
B	I	24					8.52				
E	N	25									
H	T	26									
A	E	27									
V	N	28			10.4	9.03	9.79		8.10		
I	T	29					10.5			8.83	6.18
O	I	30									
U	O	31									
R	N	32									
A	S										
L											
Concepts											
Knowledge							12.6			9.20	
Attitudes							4.88				
Behavioural Intent.											

APPENDIX 16

p-values associated with the McNemar statistics
- for Table 7.6 (BIO)

		TIME	1	TIME	2	TIME	3	INT. 1	INT. 2	INT. 3
		CAT	YES/NO	CAT	YES/NO	CAT	YES/NO			
CONCEPTS	1	.003	.001			.013	.006	.023		
	2	.011	.027	.002	.001	.037			.014	
	3									
	4									
	5									
	6									
	7									
	8									
	9		.008	.004	.000				.038	
KNOWLEDGE	1				.032					
	2		.034		.007		.010			
	3									
	4									
	5									
	6			.006	.029			.038		
	7			.005	.002				.007	
	8			.009	.003			.021		
	9	.002	.000							.023
ATTITUDES	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8							.001		.029
	9									
	10									
	11	.037								
	12									
	13	.021								
	14		.049							
	15	.001	.000	.039	.025					
	16	.047		.047						
	17									
	18									
	19									
	20									
	21									
	22									
	23		.031				.040	.035		.037
BEHAVIOURAL INTENTIONS	24					.036				
	25									
	26									
	27									
	28			.035	.003	.020		.017		
	29					.015			.012	.045
	30									
	31									
	32									
Concepts										
Knowledge						.005			.023	
Attitudes						.035				
Behavioural Intent.										

APPENDIX 17

McNemar Chisquare Statistics
- for Table 7.7 (GEOG)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1									6.10
C	2									
O	3									
N	4						6.22			
C	5					8.20				
E	6									
P	7									
T	8									
S	9									
K	1									8.10
N	2									
O	3									
W	4									
L	5									
E	6									
D	7									
G	8	8.22	6.69							5.84
E	9									
	1		4.24			12.6	8.64			
	2									
A	3	7.77								
	4									
T	5									
	6									
T	7									
	8			14.8						8.01
I	9		8.02					14.7		
	10									
T	11	11.1				8.78	7.54			
	12									
U	13	8.38	5.73							
	14	7.15	7.13	8.34			5.40			
D	15									
	16									
E	17									
	18									
S	19			11.2						
	20									
	21									
	22									
	23		5.68	8.79		12.3				8.10
B I	24						4.37		4.59	
E N	25									
H T	26									
A E	27					8.49	5.08			
V N	28		4.20				4.02			
I T	29									8.36
O I	30									
U O	31									
R N	32									
A S										
L										
Concepts Knowledge Attitudes Behavioural Intent.							16.6			

APPENDIX 18

p-values associated with the McNemar Statistics
- for Table 7.7 (GEOG)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1									.047
C	2									
O	3									
N	4						.013			
C	5					.042				
E	6									
P	7									
T	8									
S	9									
K	1									.031
N	2									
O	3									
W	4									
L	5									
E	6									
D	7									
G	8	.042	.010							.010
E	9									
	1		.040			.006	.003			
	2									
A	3	.029								
	4									
T	5									
	6									
T	7									
	8			.005						.000
I	9		.005					.001		
	10									
T	11	.025				.032	.006			
	12									
U	13	.045	.017							
	14	.028	.008	.039			.020			
D	15									
	16									
E	17									
	18									
S	19			.024						
	20									
	21									
	22									
	23		.017	.038		.006				.041
B I	24						.037		.032	
E N	25									
H T	26									
A E	27					.037	.024			
V N	28		.040				.045			
I T	29									.041
O I	30									
U O	31									
R N	32									
A S										
L										
Concepts Knowledge Attitudes Behavioural Intent.							.034			

APPENDIX 19

McNemar Chisquare Statistics
- for Table 7.8 (Maths)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1	10.5	6.06	11.8						9.36
C	2	8.78	7.26				10.5	11.2		
O	3			4.62	4.54	10.8	10.5			
N	4	11.9		8.68	5.04	9.85	4.60			
C	5					10.6			6.17	5.50
E	6	9.52	5.20	8.84	6.64					
P	7	11.8								
T	8									
S	9	16.8	9.03					6.88		
K	1		5.09		7.56	12.1	11.1			
N	2		5.39			27.3	21.2		15.1	
O	3	9.63	6.15							
W	4				5.86	14.9	11.0			10.3
L	5									
E	6	8.96						4.65		
D	7								13.8	
G	8									
E	9									8.65
	1									
	2									
A	3					5.05				
	4									
T	5									
	6									
T	7			10.7						
	8									
I	9	9.75								
	10									
T	11			9.54	4.93					
	12									
U	13					5.69			6.18	
	14									
D	15					5.87				
	16									
E	17								6.63	6.18
	18									
S	19									
	20									
	21									
	22									
	23		8.68	18.4	10.4					
B I	24									
E N	25									
H T	26									
A E	27									
V N	28		7.57		4.47				6.36	
I T	29									
O I	30									
U O	31			10.2						
R N	32									
A S										
L										
Concepts			27.0		26.6		20.1	4.96	8.59	
Knowledge							19.5			21.3
Attitudes							20.1		10.6	
Behavioural Intent.									16.9	

APPENDIX 20

P-values associated with the McNemar Chisquare Statistics - for Table 7.8 (Maths)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
CONCEPTS	1	.015	.014	.008						.009
	2	.032	.007				.001	.004		
	3			.010	.033	.005	.001			
	4	.008		.034	.025	.020	.043			
	5					.014			.046	.021
	6	.023	.023	.032	.010					
	7	.008								
	8									
	9	.001	.003					.032		
KNOWLEDGE	1		.024		.006	.007	.001			
	2		.020			.000	.000		.001	
	3	.022	.013							
	4				.015	.002	.001			.006
	5									
	6	.030						.017		
	7								.001	
	8									
	9									.013
ATTITUDES	1									
	2									
	3					.030				
	4									
	5									
	6									
	7			.029						
	8									
	9	.045								
	10									
	11			.049	.026					
	12									
	13					.001			.045	
	14									
	15					.036				
	16									
	17								.036	.045
	18									
	19									
	20									
	21									
	22									
	23		.003	.001	.001					
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28		.006		.034				.042	
	29									
	30									
	31			.037						
	32									
Concepts			.000		.001		.020	.032	.020	
Knowledge							.021			.002
Attitudes							.010		.031	
Behavioural Intent.									.001	

APPENDIX 21

McNemar Chisquare Statistics
- for Table 7.15 (Science)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
CONCEPTS	1			7.89						
	2									
	3									
	4	6.21		9.80	9.11				6.24	
	5			10.1	7.88			14.9		
	6									
	7									
	8									
	9	29.5	16.9	19.9	19.9	13.5	11.4	10.3	24.6	13.8
KNOWLEDGE	1	17.9	12.2	21.7	21.4	16.6	10.9		11.6	
	2	27.1	26.9	16.9	12.4	33.4	24.7	8.94		
	3		5.22							
	4		8.56	7.02	6.77	24.7	19.1	10.3		
	5									
	6			8.56		9.85				
	7			9.60	7.82			7.70		
	8							4.43		
	9							8.29		9.10
ATTITUDES	1	19.8	13.4	9.02		12.1		9.41		4.52
	2									
	3									
	4		5.63			17.6	16.8		12.8	11.7
	5			8.14	5.66					
	6									
	7									
	8									
	9			12.0	7.93			8.82		
	10									
	11		5.17							
	12									
	13									
	14									
	15	12.9	11.3	10.3	4.17	9.68				
	16					4.92				6.76
	17									
	18									6.95
	19	10.4	6.83	11.2	6.68					
	20									
	21					8.74				8.90
	22									
	23									
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28		5.79	12.4	7.04					
	29						5.29			
	30	22.9	8.55	10.1		13.4				
	31									
	32									
Concepts			17.0		37.6		25.4		16.5	
Knowledge			17.8		23.2		36.8			
Attitudes							22.4		16.5	26.7
Behavioural Intent.							14.1			

APPENDIX 22

p-values associated with the McNemar statistics - for Table 7.15 (Science)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
	1			.048						
C	2									
O	3									
N	4	.045		.020	.003				.044	
C	5			.017	.005			.001		
E	6									
P	7									
T	8									
S	9	.000	.000	.000	.000	.004	.001	.006	.000	.001
K	1	.000	.001	.000	.000	.001	.001		.003	
N	2	.000	.000	.001	.000	.000	.000	.012		
O	3		.022							
W	4		.003	.010	.009	.000	.000	.006		
L	5									
E	6			.040		.020				
D	7			.022	.005			.021		
G	8							.011		
E	9							.016		.011
	1	.001	.000	.031		.007		.010		.043
	2									
A	3									
	4		.018			.001	.000		.002	.003
T	5			.048	.017					
	6									
T	7									
	8									
I	9			.017	.005			.012		
	10									
T	11		.023			.028				
	12									
U	13									
	14									
D	15	.012	.001	.036	.041	.022				
	16					.036				.034
E	17									
	18									.031
S	19	.034	.001	.024	.010					
	20									
	21					.033				.012
	22									
	23									
B I	24									
E N	25									
H T	26									
A E	27									
V N	28		.016	.014	.008					
I T	29						.021			
O I	30	.000	.004	.039		.004				
U O	31									
R N	32									
A S										
L										
Concepts			.020		.000		.003		.012	
Knowledge			.013		.003		.000			
Attitudes							.004		.002	.000
Behavioural Intent.							.032			

APPENDIX 23

McNemar Chisquare Statistics
- for Table 7.22 (Maths/Science)

		TIME CAT 1	YES/NO 1	TIME CAT 2	YES/NO 2	TIME CAT 3	YES/NO 3	INT. 1	INT. 2	INT. 3
CONCEPTS	1			8.4	4.28					
	2									
	3									
	4			8.90	8.23				6.29	
	5			10.1	8.39	9.19		16.9		
	6				4.19					
	7									
	8									
	9	28.4	15.9	17.8	17.8	12.1	10.2	9.67	22.7	12.8
KNOWLEDGE	1	16.2	12.1	19.5	19.2	15.9	11.3		12.2	
	2	25.7	25.6	15.6	11.1	37.1	29.1	8.37		
	3		6.53							
	4	18.3	8.09	10.7	9.98	26.9	20.2	12.3		
	5									
	6			9.30		12.2				
	7			8.20	6.45			6.60		
	8									
	9			8.30				7.71		8.68
ATTITUDES	1	18.1	12.6			13.7		7.56		4.83
	2									
	3					16.7				6.50
	4		4.81		5.38				12.2	
	5									
	6									
	7									
	8									
	9				9.22			11.4		
	10									
	11					9.40				
	12		4.09					7.49		
	13									
	14									
	15	10.9	9.40							
	16									
	17									
	18									
	19	10.5	8.60	9.7	6.04				10.1	
	20									
	21					8.94			6.11	
	22									
	23									
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28		6.18	9.29	5.75					
	29						4.45			
	30	22.2	9.27	9.8		13.4				
	31									
	32									
Concepts			17.8		38.6		23.9		15.8	
Knowledge			19.4		20.6		35.7		10.7	13.6
Attitudes									15.3	24.7
Behavioural Intent.									7.75	

APPENDIX 24

p-values associated with the McNemar statistics
- for Table 7.22 (Maths/Science)

		TIME CAT (1)	1 YES/NO	TIME CAT (2)	2 YES/NO	TIME CAT (3)	3 YES/NO	INT. 1	INT. 2	INT. 3
CONCEPTS	1			.038	.039					
	2									
	3									
	4			.030	.004				.043	
	5			.018	.004	.030		.000		
	6				.041					
	7									
	8									
	9	.000	.000	.001	.000	.010	.001	.010	.000	.002
KNOWLEDGE	1	.001	.013	.000	.000	.001	.004		.002	
	2	.000	.001	.001	.001	.000	.001	.020		
	3		.000							
	4	.000	.011	.013	.002	.000	.000	.002		
	5									
	6			.030		.010				
	7			.042	.011			.040		
	8									
	9			.020				.021		.013
ATTITUDES	1	.001	.000			.003		.023		.040
	2									
	3					.001	.000			.010
	4		.030		.020				.002	
	5									
	6									
	7									
	8									
	9				.002			.003		
	10									
	11					.025				
	12		.043					.024		
	13									
	14									
	15	.030	.002							
	16									
	17									
	18									
	19	.032	.003	.050	.014				.039	
	20									
	21					.040			.014	
	22									
	23									
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28		.013	.030	.020					
	29						.035			
	30	.000	.002	.045		.004				
	31									
	32									
Concepts			.013		.000		.004		.015	
Knowledge			.010		.010		.000		.020	.034
Attitudes									.004	.000
Behavioural Intent.									.051	

APPENDIX 25

McNemar Chisquare Statistics
- for Table 7.29 (Bio/Geog)

		TIME CAT	1 YES/NO	TIME CAT	2 YES/NO	TIME CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
CONCEPTS	1					4.02				
	2		4.83	5.84						5.72
	3									
	4									
	5				4.44					
	6									
	7			5.81						
	8									
	9									
KNOWLEDGE	1								6.54	
	2						5.01			
	3			9.57						
	4									
	5									
	6									
	7									
	8									
	9	8.02	7.22		4.21					
ATTITUDES	1					7.21				
	2									
	3	9.64	7.32					5.08		5.57
	4						4.38		7.01	7.25
	5									
	6									
	7									
	8									
	9			9.97		4.14		12.4		
	10									
	11									
	12						4.12		8.09	
	13									
	14									
	15	12.3	11.1			8.50				
	16					6.62	5.39		7.12	
	17									
	18				5.01					
	19			9.88						
	20	7.41								
	21									
	22									
	23	10.5	9.38	11.5	4.01				5.75	4.32
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28									
	29									
	30									
	31									
	32									
Concepts										
Knowledge									12.9	
Attitudes							19.0			
Behavioural Intent.										7.14

APPENDIX 26

p-values associated with the McNemar statistics
- for Table 7.29 (Bio/Geog)

		TIME 1 CAT	1 YES/NO	TIME 2 CAT	2 YES/NO	TIME 3 CAT	3 YES/NO	INT. 1	INT. 2	INT. 3
CONCEPTS	1					.049				
	2		.030	.025						.020
	3									
	4									
	5				.040					
	6									
	7			.032						
	8									
	9									
KNOWLEDGE	1								.040	
	2						.030			
	3			.023						
	4									
	5									
	6									
	7									
	8									
	9	.046	.010		.040					
ATTITUDES	1					.031				
	2									
	3	.047	.010					.024		.032
	4						.040		.030	.030
	5									
	6									
	7									
	8									
	9			.041		.024		.002		
	10									
	11									
	12						.042		.018	
	13									
	14									
	15	.015	.001			.040				
	16					.040	.020		.030	
	17									
	18				.025					
	19			.042						
	20	.040								
	21									
	22									
	23	.032	.002	.022	.049				.020	.040
BEHAVIOURAL INTENTIONS	24									
	25									
	26									
	27									
	28									
	29									
	30									
	31									
	32									
Concepts										
Knowledge									.044	
Attitudes							.014			
Behavioural Intent.										.031