USING THE TOPIC "WATER MANAGEMENT IN UMTATA" TO PROMOTE THE USE OF AN ENVIRONMENTAL APPROACH IN THE TEACHING OF GEOGRAPHY

THESIS

Submitted in Partial Fulfilment of the Requirements
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by

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DECLARATION

I, **Joyce Nothemba Nduna** sincerely and solemnly declare that the copy of the half-thesis submitted by me in October 1994 is original. It is my own work and has not been submitted for a degree at any other university. The product is the result of my efforts through the professional guidance of the supervisor whose name and signature appear below.

CANDIDATE : **J N Nduna**

CANDIDATE'S SIGNATURE : 

SUPERVISOR : **Ms. U van Harmelen**

SUPERVISOR'S SIGNATURE : 

DEDICATION

To my late father

ELLIOT MDIDI MSENGANA

for having taught me how to persevere in life

and to trust in God

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ABSTRACT

This study first offers a critique of some conventional approaches to environmental education and geography. The critique is followed by an analysis of current learning theories which underpin environmental and geographical thinking. On the basis of this analysis an environmental approach to the teaching of geography is identified. Within the broad theoretical context provided by debates on the importance of environmental education for the solution of environmental problems, the study promotes student teachers' understanding of an environmental approach in the teaching of geography at Transkei College of Education. Water management, a section of the geography syllabus, is selected to illustrate the process and implementation of such an approach in geography. The educational effectiveness of an environmental approach with regard to the students' conceptual understanding of water management is evaluated. The study as a whole is set within the general literature of environmental education, and particularly that of education **for** the environment.

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CHAPTER ONE

INTRODUCTION

1.1 THE CONTEXT OF THE RESEARCH

The world is faced by environmental problems which originate at local, regional and global levels (Hurry, 1985). These problems are not only physical or natural but are also related to factors such as the irresponsible dumping of waste, species extinction, ozone depletion, poverty and lack of primary health care (Allaby, 1986; Irwin, 1991). Numerous examples of disasters which are largely caused by human actions around the world have given rise to the term "un-natural disaster" as a more appropriate description of most environmental catastrophes (Ball, 1975; O'Keef, Westage and Wisner, 1976; Tiranti, 1977).

South Africa is not only vulnerable to global environmental problems but in addition has regional problems peculiar to her bio-physical and socio-historical circumstances (Huntley, Siegfried and Sunter, 1989). The rapid population growth places high demands on food production and resources utilization (Hurry, 1985). The provision of water, one of the basic resources, is an important environmental issue for the majority of South Africans (Wilson and Ramphele, 1989).

Environmental education is perceived to be an essential strategy for addressing environmental problems. In response to global environmental issues, the late forties and the fifties of this century saw the establishment of several international agencies concerned with environmental issues and environmental education (Irwin, 1991). Most notable among these were the International Union for the Conservation of Nature and Natural Resources (IUCN), the World Wildlife Fund, UNESCO and the United Nations Environment Programme (UNEP). UNEP, together with UNESCO, organised the first Intergovernmental Conference on environmental education at Tbilisi in the USSR in 1977 (Neal and Palmer, 1990). This conference resulted in a declaration of 12 principles which are now referred to as the 'Tbilisi Principles of environmental education' (UNEP, 1977). These guiding principles provided a foundation for the practice of environmental education on a global, national and regional scale, and were reaffirmed by the international conference held in Moscow in 1987 (Irwin, 1990).

Stimulated by increasing interest and concern and by international developments, the first national conference on Environmental Education in southern Africa took place in 1982 (Hurry, 1985). This conference led to the establishment of the Environmental Education Association of Southern Africa (EEASA), which has played a significant developmental and co-ordinating role in promoting environmental education in the region.

A pioneering role in the implementation of environmental education in South Africa has been played by a number of non-government conservation organisations which include the following: The Wildlife Society of Southern Africa, in particular the Society's Umgeni Valley Project, which started in Natal in 1973; and the National Environmental Awareness Council (NEAC), which started in Soweto in 1974 (Irwin, 1991).

Further important initiatives in the development of environmental education in South Africa followed the tabling in 1989 of a White Paper on Environmental Education in the tricameral parliament (Schreuder, 1990). This paper embraced the 'Tbilisi Principles' and the internationally accepted concept of environmental education. Mention also needs to be made of the concern of several 'liberation movements' about environmental issues and the need for environmental education. The African National Congress is reported to be considering an 'Environmental Charter' to parallel the Freedom Charter (Sisulu and Sangweni, 1990). The Pan Africanist Congress and Azapo are also addressing the issue of environmental education (Desai, 1990).

Prior to the 1980s, increasing public awareness of environmental problems in South Africa was reflected in efforts which ranged from the stimulation of positive interest in conservation and the responsible use of natural resources to the learning of ecological interrelationships (Fuggle and Rabie,

1983; Okut-Uma and Wereko-Brobby, 1985; Huntley, 1989; Wilson and Ramphele, 1989). It was assumed that if students learned more about ecological interrelationships, their awareness of the need for conservation would be enhanced and they would be more likely to behave appropriately (Marker, 1984). Schools and environmental education field centres emphasized the teaching of ecological principles with limited, if any, reference to how these help us understand environmental problems, or how those environmental problems possess social, political, historical and economic dimensions. This point is illustrated by the content of the ecology component of several South African school textbooks (Claasens et al., 1985; Dutoit et al., 1985; Thienel et al., 1985), an issue of particular significance in view of the influential role textbooks play in guiding teaching in South African schools (Wagiet and Mackenzie, 1992).

Most efforts to make school children aware of the environment and to encourage in them a sense of responsibility towards the environment have taken place primarily outside the formal education sector. Since the 1980s there has been increased pressure on education authorities to accept responsibility for assimilating the principles of Environmental Education into South African school curricula (Martin and Wheeler, 1975; Saveland, 1976; UNESCO, 1980; Irwin, 1990). This demand is supported by the Tbilisi Declaration (UNEP, 1977) which suggests that

environmental education should be a continuous life-long process beginning at the pre-school level and continuing through all formal and non-formal stages. The White Paper on Environmental Education (1989) has also recognized the need for all prospective teachers to be made aware of the aims, principles and methodology appropriate to an environmental approach. However, few studies had been conducted in South Africa to investigate what teachers know about environmental issues and problems (Fuggle, 1982; Irwin, 1990).

A currently accepted environmental approach places an emphasis on education **for** the environment. Here the stress is on action as the students develop the resources and capacities that are needed for sustainable living (Fien, 1993). This approach emphasizes teaching strategies which encourage active pupil participation in a learning process which aims at the development of skills relating to decision making, evaluation and critical thinking, in order to promote lifestyles that are compatible with the sustainable and equitable use of resources. In so doing, it builds on education **about** and **in** the environment to help develop an informed concern for the environment, a sensitive environmental ethic, and the skills for participating in environmental protection and improvement. (Chapter 2 will explore this approach in more detail.)

An environmental approach in teaching is generally accepted as an interdisciplinary approach that places emphasis on people-environment issues (Hall, 1984). Although there has been a call for the infusion of environment and development issues into all disciplines (cross-curricular), the reality in South Africa is that we have discrete subjects. It is the responsibility of particular subjects to promote the aims of environmental education through the adoption of an environmental approach.

Environmental education can only be successful in schools if pre-service and in-service teachers are encouraged to develop the necessary teaching skills and the skills needed to act responsibly towards the environment. The influence teachers can have on students' perspectives on environmental issues is, in turn, partly dependent upon their own knowledge. It is therefore the responsibility of teacher-educators in pre-service and in-service centres to educate prospective and practising teachers in how to use their teaching subjects as vehicles to promote the aims of environmental education through the adoption of an environmental approach.

Geographers are particularly well placed to provide the skills needed to address South Africa's environmental challenges. Part of their failure to do so may be ascribed to the insulation and poor communication between human and physical specialists. An environmental approach which focuses on both the physical

properties of natural resources and how and why society uses them is needed in South African geography.

It must, however, be emphasized that the subjects will not thereby be so subsumed by environmental education that they lose their character and their uniqueness. Rather, it is argued that the use of an environmental approach in the teaching of geography will not only achieve the aims of both environmental and geographical education but will also address the contemporary dilemma in geography, which is the split between environmental science, physical and human geography.

The role of teachers as agents of change has been regarded as vital if environmental education is one of the social agencies through which the transformation to an ecologically sustainable society is to be achieved (Ham and Sewing, 1987/88; Stevenson, 1987; Robottom, 1984; Huckle 1994). In other words, teachers are the key to success in environmental education since they have an opportunity to 'spread the gospel' of environmental education in their classrooms. The preparation of teachers has been recognized by successive UNESCO-UNEP conferences and reports as a major priority for research and action in promoting environmental education (UNESCO, 1980; Wilke, Peyton and Hungerford, 1987; UNESCO-UNEP, 1988). It is against this background that this study undertakes to promote the use of such an approach at Transkei College of Education.

1.2 PROBLEM STATEMENT AND JUSTIFICATION

While much attention has been given to both the pre-service and in-service areas in official documents, the current status of environmental education in teacher education remains at an unsatisfactory level. As Wilke, Peyton and Hungerford (1987: 1) write, "Few, if any, teacher training programmes adequately prepare teachers to effectively achieve the goals of environmental education in their classrooms." Teacher-educators could therefore, play a significant role in the success of environmental education.

However, to date (1993) the Transkei Education Department has done comparatively little to encourage environmental education in schools. Even those school subjects which are particularly relevant in terms of creating an awareness of the natural and social environment continue to be taught without giving due regard either to environmental issues or to the skills needed to promote environmental responsibility. This state of affairs has led to the failure of geography teachers amongst others to capitalize on the opportunities provided by the current syllabus to promote the aims of environmental education. The call for an environmental emphasis in formal education demands adaptation in traditional classroom approaches and practices (Walford, 1981).

1.3 GOALS OF THE RESEARCH

The goal of this study is to promote the use of an environmental approach in the teaching of geography so that the aims of both environmental and geographical education can be achieved. In achieving this goal the study will form a part of a broader study conducted by the Rhodes University Education Department which aims to develop a pattern of understanding of teachers' perspectives and images of environmental education related to their subject areas. This study therefore forms one of a series of investigations into teachers' thinking about environmental education.

1.4 RESEARCH LOCATION

This study was conducted in the former independent state of Transkei (Fig. 1.1). Since at the conclusion of the research the Transkei structures were still in place, throughout the dissertation Transkei is referred to as a separate entity.
The use of an environmental approach in the teaching of geography was promoted amongst the third-year students at Transkei College of Education in Umtata.

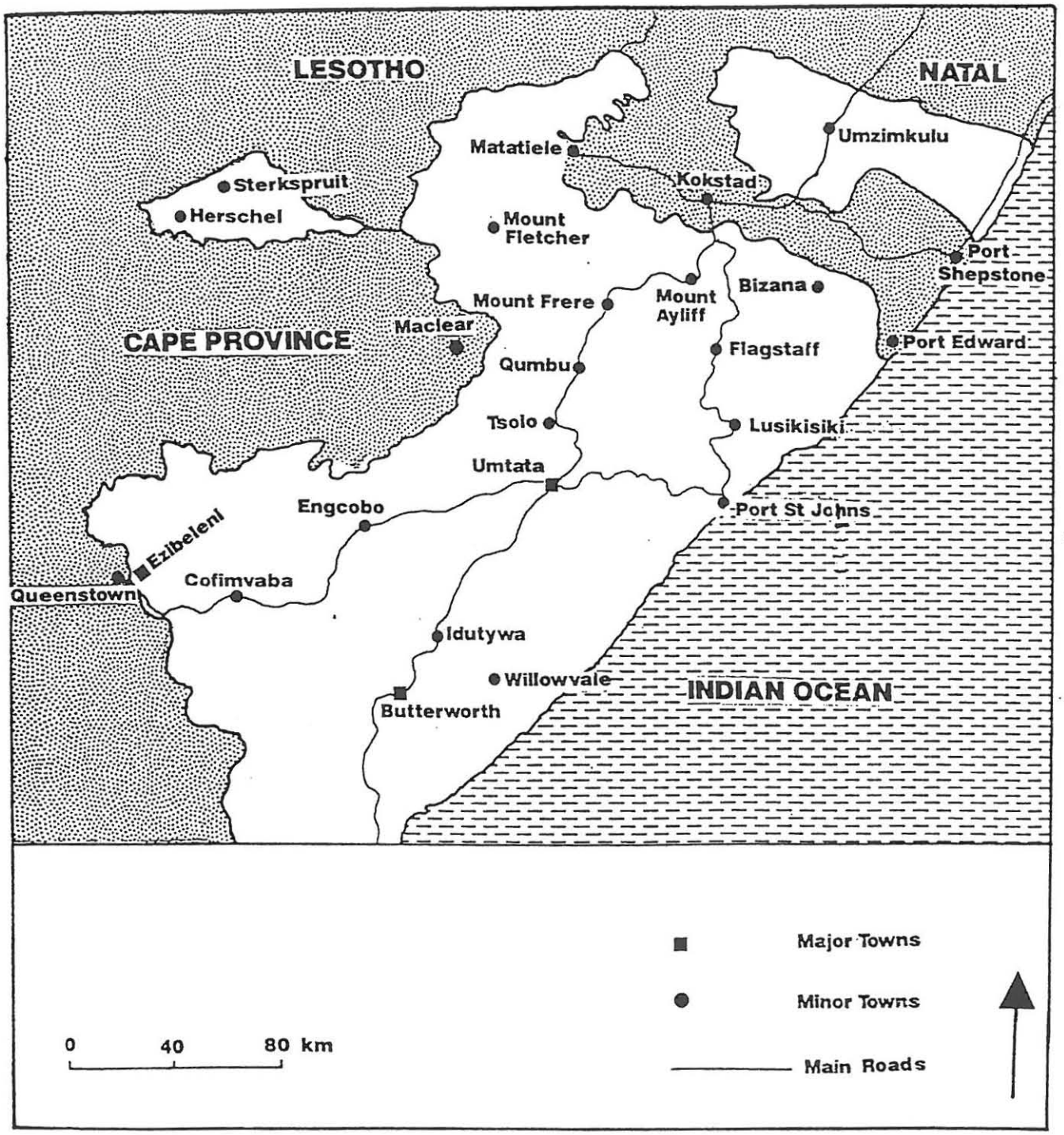

Figure 1.1 The Location of Transkei

1.5 THE STRUCTURE OF THE STUDY

The present study has been set out in seven chapters. Following the introduction, which portrays how the growing awareness of environmental problems has contributed to calls for environmental education as a means of solving them, is a theoretical analysis of the relationship between the aims, approaches and learning theory of environmental education and geography. Paradigm shifts in both environmental education and geography are examined and a critique of some conventional approaches is followed by a description of a socially critical learning theory which underpins the implementation of the current environmental approach.

The participatory action research model employed in this study was designed so that the respondents could benefit from their involvement. An analysis of this methodology and the procedures followed in the research form the subject of chapter 3. The results of the diagnostic test are set out and analysed in chapter 4, while Chapter 5 focuses attention on field research.

The results of the two-tier test are outlined and compared with those of an open-ended test in chapter 6, thereby reflecting the effectiveness of the teaching unit. The extent to which the environmental approach has been effective in improving the student teachers' conceptual understanding is also portrayed.

A summary of the research findings and conclusions is set out in the final chapter and some recommendations are put forward which deal with how an environmental approach in the teaching of all school subjects may best be stimulated and encouraged in Transkei.

CHAPTER TWO

A THEORETICAL ANALYSIS OF THE RELATIONSHIP BETWEEN THE AIMS, APPROACHES AND LEARNING THEORY OF ENVIRONMENTAL EDUCATION AND GEOGRAPHY

2.1 INTRODUCTION

Throughout the world there is a growing awareness of the fact that the life support systems of this planet are under severe strain (SAGS Newsletter, 1993). Environmental issues which are both physical and human in nature have become cause for great concern (Allaby, 1986; Wilson and Ramphele, 1989). Attempts, not least by geographers, are being made throughout the world to encourage people to participate actively in environmental protection and improvement (Fien, 1993).

Against this background this chapter not only explores paradigm shifts in environmental and geographical education but also examines the relationship between the aims, approaches and learning theory of environmental education and geography, thereby attempting to portray the extent to which a subject such as geography has the potential to meet the needs of environmental education.

2.2 TRENDS, DEFINITIONS AND PRINCIPLES IN ENVIRONMENTAL EDUCATION

A survey of articles in the Southern African Journal of Environmental Education (1984-1990) and the Environmental Education Bulletin (1989-1991) reveals that, before the Environmental Education Association of Southern Africa (EEASA) conference of 1990, most environmental education initiatives attempted to raise environmental awareness in order to conserve nature (Irwin, 1991). Environmental education was seen as a process by which values and attitudes could be inculcated and behaviour changed to reduce environmental damage.

2.2.1 A CRITIQUE OF PREVIOUS TRENDS IN ENVIRONMENTAL EDUCATION

The following discussion considers earlier approaches which placed an emphasis on education **about** and **in** the environment and identifies the criticisms levelled against these approaches.

(i) The first feature which distinguishes these earlier approaches is their reductionist perspective, in the sense that these approaches address only the biophysical dimensions of the environmental crisis. The outcome of this orientation is environmental education which draws exclusively on the natural sciences, particularly

ecology (Paxton, 1994).

More recent international and southern African literature advocates a more comprehensive approach which recognizes that meaningful environmental education requires an examination of social, political, economic, historical as well as biophysical factors (Greenall, 1987; Irwin, 1989; O'Donoghue and McNaught, 1989; Wilson and Ramphele, 1989; Ramphele, 1991).

(ii) The second distinguishing feature is the adoption of a transmission approach to education, learning and social change. This approach is characterized by the communication of appropriate conservation messages from experts (most often scientists) to specific target groups such as teachers, pupils and the public, with the intention of promoting awareness and behaviour change (Robottom, 1991; O'Donoghue, 1993).

As passive recipients of transmitted messages, people might be unable to comprehend, critically analyse and interact with the messages they receive. "The idea of message communication to cause behaviour change is questionable as a strategy of education ... [it] cannot accommodate the realities of how people come to socially construct and to change the way they see the world" (O'Donoghue, 1993: 30).

An alternative to "transmission pedagogy" (Dunne and Johnston, 1992: 518) has been suggested by Robottom (1991: i) in his

comments on a workshop he had attended:

> Education seemed to be perceived as a one-way delivery system from experts to lay people, rather than as a process whereby lay people could generate information, knowledge or understanding about the Greenhouse issue.

Several authors have pointed out that active participation in addressing environmental problems is more likely when people have been involved in identifying suitable actions. The public are " a source of useful ideas [and] a vehicle for social change" (Miller, 1993: 57); " real change is most likely to come from ordinary people" (Wynberg, 1993: xxi).

(iii) The third feature identified in the early approaches is individualism and behaviourism, manifested in an emphasis on individual responsibility for environmental problems and on behaviour change as a solution. Emphasis is placed on individual values and attitudes as determinants of behaviour.

It has been recognized that responsibility for one's behaviour does not lie exclusively with the individual but also with society or the community. Environmental problems should not be removed from their social (including political, economic, historical) context. Robottom and Hart (1991: 9) emphasize the significance of society as opposed to the individual in addressing environmental problems, and suggest that it is more realistic to view environmental problems as

> social constructions whose meaning and significance metamorphose, wax and wane according to changeable human interest ... Environmental issues are ... always political struggles, and collective action is usually more productive than individual efforts in the resolution of political struggles.

Although education **in** the environment uses students' fieldwork experiences as a medium for education, its aim is only to provide students with an appreciation of the environment through direct contact with it. Such experiences may, however, develop skills for data gathering as well as social skills such as co-operation and group responsibility. Several environmental educators have argued that education **about** and **in** the environment are valuable in so far as they are used to provide skills and knowledge to support the transformative intentions of education **for** the environment (Robottom, 1984; Maher, 1986; Fien, 1988, 1991). Thus, the perception is that effective environmental education only takes place when the overt intention of the programme is education **for** the environment.

2.2.2 EDUCATION FOR THE ENVIRONMENT

Education **for** the environment aims to engage students in the exploration and resolution of environmental issues; to promote lifestyles that are compatible with the sustainable and equitable use of resources; to help develop an informed concern for the environment, a sensitive environmental ethic, and the skills for participating in environmental protection and improvement. This is not a top-down approach but a

co-operative process through which people might develop the capacities to solve the pressing problems of sustainability and social justice that confront modern society.

The aim of environmental sustainability is to prevent the environment from deteriorating so that it can continue to support future generations. An attempt to maintain a balance between the use and the restoration of the life support systems of the earth is encouraged. Thus environmental sustainability provides a sense of environmental continuity and stability (Huckle, 1994) and is linked to education for the environment since it emphasizes environmental protection and improvement.

The role of environmental education as perceived in the current approach is to equip societies and communities to reflect critically on the structures and processes which underlie and perpetuate local and global environmental problems (Harber, 1990; Orr, 1992), and to meaningfully address them. Such education is socially critical (Huckle, 1991; Fien, 1993; Greenall, Gough and Robottom, 1993).

The conceptual implications of education **for** the environment require a re-examination of previously accepted definitions and principles which underpin the implementation of environmental education.

2.2.3 DEFINITIONS AND PRINCIPLES OF ENVIRONMENTAL EDUCATION

The following is the most frequently referred to and widely accepted definition of environmental education, developed by the International Union for the Conservation of Nature and Natural Resources (IUCN) in 1971:

> Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness amongst people, their culture and their bio-physical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behaviour about issues concerning environmental quality. (IUCN, 1971)

Although it is evident from this definition that environmental education involves the cognitive and the affective domains of human development, it is possible to infer a continued emphasis on individual attitudes and behaviour. Another example is the Council for the Environment's (1984) definition of environmental education as "planned learning programmes which impart knowledge, skills and values to participants in order to develop life-styles in harmony with the environment in its totality". A linear relationship between knowledge, attitudes and behaviour is assumed, which suggests that this definition is based upon a transmission model.

Valuable as these definitions are, as is the case with all definitions, they are open to interpretation from a variety of perspectives. That interpretation will depend on the

theoretical perspective of the reader. Thus, for example, a reader might fail to recognize an implicit emphasis on the need for an environmental approach to be located within the social construction of knowledge.

The definitions alone do not provide us with sufficient understanding of an approach such as the one we have described as education **for** the environment. It is therefore necessary to unpack the guiding principles which have up to now underpinned the implementation of environmental education programmes. The Tbilisi Principles (Table 2.1) since their adoption in 1977 have provided the most comprehensive set of guidelines for environmental education.

An analysis of the Tbilisi Principles made in the light of current trends in environmental education continues to be valuable as they lend themselves to the sort of interpretation which is desired by education **for** the environment. For example, the first of the twelve Tbilisi Principles points to the significance of an understanding of factors other than the biophysical. The environmental crisis is not treated as a matter of conservation issues to the exclusion of social, political and economic concerns. The fifth principle also places emphasis on the historical dimension of current and potential environmental situations.

The significance of collaboration or collective action, as against individualism, in the prevention and solution of

environmental problems, is recognised by the sixth principle. The eighth principle discourages transmission pedagogy by promoting the active participation of learners in planning their learning experiences and decision making. The ninth principle suggests that environmental education should be community-based. Emphasis is placed on environmental sensitivity to the learner's own community in the early years.

TABLE 2.1 : GUIDING PRINCIPLES FOR EFFECTIVE ENVIRONMENTAL EDUCATION

Environmental Education should:

* consider the environment in its totality - natural and built, technological and social (economic, political, cultural-historical, moral, aesthetic);
* be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and nonformal stages;
* be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;
* examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;
* focus on current and potential environmental situations while taking into account the historical perspective;
* promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems;
* explicitly consider environmental aspects in plans for development and growth;
* enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
* relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;
* help learners discover the symptoms and real causes of environmental problems;
* emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;
* utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.

It is recognized that the Tbilisi Principles - as is the case with any guidelines for education - are also open to different interpretations. These interpretations will, to a large extent, depend on the world view of the interpreters and their perspectives on what constitutes knowledge and the acquisition of knowledge. Therefore, this highlights the need for a thorough theoretical understanding of any approach to education, not least the current approach of education **for** the environment.

The discussion in the following section is an attempt to unpack the theory underpinning education **for** the environment as an approach to geographical education.

2.3 THE IDENTIFICATION OF CRITERIA NECESSARY FOR AN ENVIRONMENTAL APPROACH TO GEOGRAPHICAL EDUCATION

The criteria below reflect Fien's (1993) guiding principles for education which aims at developing the critical thinking, reflection and action skills needed for sustainable living. These guiding principles were drawn up in response to the implementation of education for the environment, and were adapted and looked at from the perspective of a geography teacher. Fien's guidelines in relation to the Tbilisi Principles have been used to provide criteria for critical teaching in geography which is in line with education for the environment.

In the light of the basic principles of education for the environment discussed above, an environmental approach to education should:

2.3.1 examine social, political, economic, historical as well as biophysical factors and their interrelationships and interdependence, instead of emphasizing nature only.

For geography this stresses the need to move away from the compartmentalization which characterizes the subject in South Africa. The failure of geographers to provide the skills needed to address South Africa's environmental challenges may be ascribed to the insulation and poor communication between human and physical specialists (Vogel, 1992; Unwin; 1992). An integrated human-environment approach (Kates, 1987), which focuses on both the physical properties of natural resources and how and why society uses them, is needed in geography. (This 'missing link' in geography was recognized as early as the beginning of the 1980s [Preston-Whyte, 1982].) By adopting an interactive approach that bridges human and physical geography, local geographers can unravel some of the complex environmental agencies operating in the South African context.

2.3.2 be participatory and practice-based. Active participation should be encouraged by providing learning experiences through which people may take a place in society as informed, committed and active

citizens who are capable of playing a part in making their society a better place in which to live by speaking out and acting against social and ecological injustice.

The implications for the geography teacher are that geography should be made more relevant to the life of the child within his environment. This reinforces the emphasis on learner-centred teaching strategies which include fieldwork and role playing.

2.3.3 be enquiry-based in order to encourage participants to adopt a research stance towards their own environmental education practices. This will enable current beliefs and practices to be regarded as problematic, as open to self- and peer analysis and critique, and as having the potential for improvement through participant research.

Geography teachers should not only evaluate their teaching methodologies but also create opportunities for their students and colleagues to evaluate their teaching approaches.

2.3.4 provide an opportunity for critical thinking and evaluation of environmental policies, resources and practices so that participants can be empowered to make appropriate changes to achieve the environmental education objectives they favour.

2.3.5 provide an opportunity for the development of problem-solving skills necessary for the improvement of the quality and sustainability of natural and social environments.

2.3.6 promote conceptualization and conceptual development rather than factual recall. Conceptual understanding lies at the heart of an environmental approach since this approach is concerned with the development of those skills and values related to critical thinking.

The above three criteria suggest a shift in teaching methodology. The acquisition of concepts, skills and values requires approaches to teaching very different from those of the traditional classroom. This stresses the need to move away from the transmission of facts or "teacher-tell" to the development of skills necessary for sustainable living.

2.3.7 be collaborative because collective action is usually more productive than individual efforts in controlling the influences that act against improvements in natural and social environments. Working collaboratively makes it easier to recognize institutional pressures that may be constraining transformative practices.

2.3.8 be community-based and involve participants in the active investigation and resolution of real-world

problems of relevance to the communities in which they live. Participants should be active members of community organizations working towards similar social ends.

The above two guidelines reinforce the need for joint action in geography and the need to use the local natural and social environments for field research. Geography teachers should not only work together but should also work with other educators in other disciplines.

Of particular importance to the geography teacher is that an environmental approach should provide opportunities for dialogue, encounter and reflection. Dialogue can be seen as a vehicle for the development of better understanding between epistemologies, as well as an appreciation of the value of different forms of knowledge (Paxton, 1994). In addition, dialogue plays a significant role in processes of reflective learning. An experiential encounter with environmental problems in the real world beyond books and the thoughtful consideration which enables a critique of the underlying causes of environmental problems are significant aspects of learning and teaching for social change.

The following section examines paradigm shifts in geography and explores the manner in which current thinking has influenced the geography syllabus. This analysis will be followed by a consideration of the relationship between the

environmental paradigm in geography and current trends in environmental education.

2.4 PARADIGM SHIFTS IN GEOGRAPHY

Four approaches to geography knowledge have been identified by Hall (1984). They are :

2.4.1 Empiricism

The exploration of the unknown world was devoted to the collection of information without any necessary desire to search for principles or cause/effect relationships which might bring pattern, order and regularity to the recorded facts. Knowledge was presented as discrete facts gained through sense perception and intuition. This viewpoint was dominant in geography teaching up to the 1960s. The emphasis upon empirical description produced the transmission style of teaching "with the image of the student mind as a bucket" (Hall, 1984: 3). In other words, emphasis was on rote learning. Passiveness on the part of the learners and "teacher-tell" were dominant.

2.4.2 Rationalism

Rationalism represents a shift away from the empiricist claim that sense perception is the fundamental route to knowledge. In this perspective, the function of the mind is perceived to be actively constructing external reality rather than just

recording it: Knowledge is therefore founded upon the innate power of the mind to organize, interprete, relate and anticipate events. Ideas, concepts, models and theories are used to explain processes, cause-effect relationships and classificatory procedures. Although the students' minds were given an opportunity to work at levels which were much more demanding than the recording of facts, a transmissive style of geography teaching in a formal classroom setting was still dominant.

Positivism

Positivism represents a move away from the descriptive methodologies of empiricism and rationalism to the quantitative approach associated with scientific systematic studies. This approach is characterized by an emphasis on analytical reasoning and a search for general principles. The 'new geography' of the 1960s and the 1970s adopted the positivist perspective and the quantitative approach formed the basis of school geographies in Britain (Geography 14-18, 1980), in the USA (High School Geography Project, 1981) and in other parts of the Western world. The 1973 syllabus introduced South African schools to this perspective. The influence of the quantitative paradigm in the 1973 syllabus is revealed in the orderly progression of information and its systematic analysis, while in both the 1985 Revised Syllabus and the 1993 Draft Core Syllabus it is revealed in the emphasis on the acquisition of cognitive skills, on quantitative analysis

rather than on description, and on the 'scientific' approach to learner-centred activities.

Humanism

The 'new geography' was criticized for ignoring 'man's role in the environment. This negative reaction of geographers to positivism had its roots in the ideology of social realism or neo-Marxism, which portrays the individual as an agent capable of interpreting his environment from his own personal knowledge and experiences (Gould, 1985; Johnston, 1985). Emphasis is placed on the contribution of personal knowledge, experience, feelings and values to the generation and utilization of knowledge.

In educational terms the humanist paradigm emphasizes the development of the "whole child" and therefore reflects the increasing importance placed on the development of the affective domain. In a geographical context this approach led to a concern for human and regional geography, which many geographers felt had been under-emphasized in the 'new geography'. While qualitative in nature, regional and human studies in geography are approached with an issues-based stance. The 1985 and the 1993 syllabuses reflect the influence of humanistic perspectives in the greater emphasis placed on an issues-based approach to themes such as urbanization, rural problems and solutions, and environmental management.

Although the humanistic approaches are valuable in developing care and concern for the environment, they have been criticized for over-emphasizing "the role of the ego" (Hall: 7) in a world that needs modern science and technology. This has prompted geographers to search for an approach better suited to the needs of pupils in terms of the reality of the 1980s and beyond.

Environmentalism or the ecological perspective

This approach developed in response to the perceived need for bridging the gap between physical and human geography so as to stress man-land relationships.

The following diagram shows how some of the features of the approaches discussed above may be absorbed into the geography classroom through the adoption of an issues-based people-environment approach to the selection of knowledge.

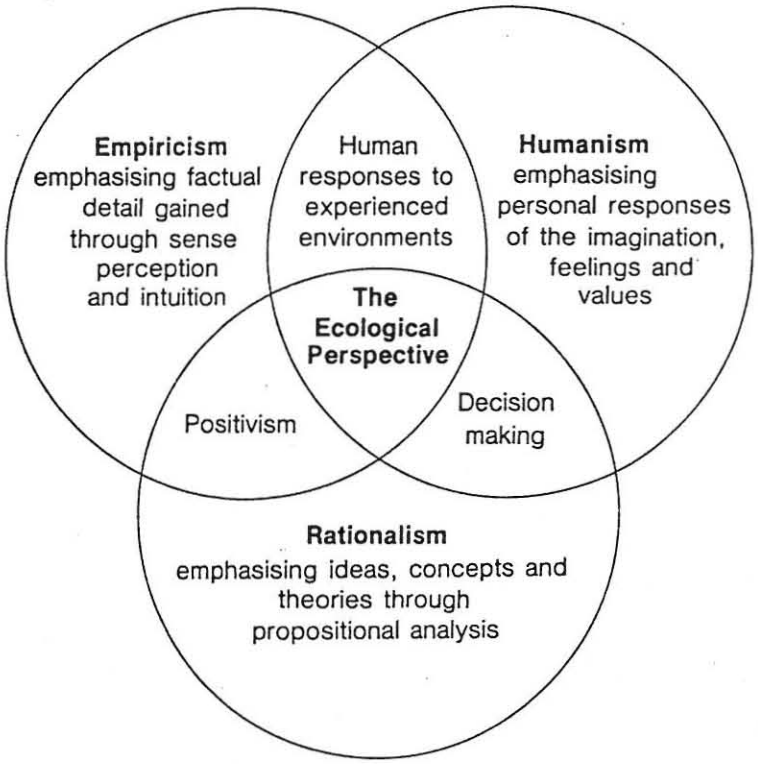

FIGURE 2.1 **The people-environment approach to knowledge at the intersection of empiricism, rationalism and humanism (Hall, in Fien, Gerber and Wilson, 1984: 9)**

From the above diagram it is evident that geography has the potential to make a contribution to societies whose children are competent to judge human issues with the sympathy of humanism, the detail of empiricism and the rigour of rationalism.

Hall (1984) has also shown how an emphasis on the people-environment approach can enable geographers' views of knowledge to respond to the emerging cultural outlooks of the late 20th century. This 'open' approach to knowledge was also adopted by the British Schools Council Geography 16-19 Project in the development of courses and teaching materials (Schools Council Geography Curriculum Project 16-19, 1980).

Environmentalism has therefore been regarded as a unifying paradigm which strengthens in the minds of all geographers a sense of common purpose irrespective of speciality. As early as 1982, environmentalism had been regarded as a "missing link" which could improve the status of geography which seemed to face the danger of "academic erosion of territory and status" (Preston-Whyte, 1982).

2.5 THE RELATIONSHIP BETWEEN THE ENVIRONMENTAL PARADIGM IN GEOGRAPHY AND CURRENT TRENDS IN ENVIRONMENTAL EDUCATION

In line with current thinking in environmental education, knowledge in the ecological paradigm is not seen as information, but as an activity which constitutes an inquiry.

The mind is given an opportunity to create an open, self-critical and evolving system of knowledge.

The ecological approach to knowledge in geography makes contemporary people-environment issues at various levels the focus of course construction. Environmentalism places emphasis on the study of people-environment issues and provides a structure for the selection of worthwhile content and learning experiences. The strength of this approach is its openness and flexibility.

The environmental paradigm as an approach to the teaching of geography has laid the foundations for a geography which is able to move beyond the boundaries of a compartmentalized and divided discipline. By incorporating the criteria which underpin education **for** the environment into the paradigm, the bridge which Hall (1984) identified may be strengthened in geography. This will also provide the methodology which will ensure the continued strength of geography as a discipline in its own right. In this way, not only the aims of environmental education will be achieved but also those of geography.

The environmental paradigm in geography can, however, be interpreted in various ways and could lead to a continued emphasis on content rather than on methodology. For example, a list of over twenty people-environment themes for study, which give rise to contemporary environmental issues, has been suggested (Hall, 1984). This may create the impression that

the environmental paradigm is issues-based and its adoption means the teaching of topics **about** the environment. This, again, highlights the need for a thorough theoretical understanding of education **for** the environment as the currently accepted approach to education.

The extent to which the currently implemented geography syllabuses provide the potential for the use of this approach to education is examined in the section below.

2.6 EDUCATION FOR THE ENVIRONMENT AND CURRENT PRACTICES IN GEOGRAPHICAL EDUCATION

Current practices in geographical education from the Junior Primary to the Senior Secondary Phase were identified through an examination of the following syllabuses: the 1979 Geography Syllabus, the 1985 Revised Geography Syllabus, the 1993 Draft Core Syllabus and that proposed by Nightingale (1993).

In dealing with the aims, objectives and approaches to the teaching of geography, the 1985 Revised Geography Syllabus and the 1993 Draft Core Syllabus are referred to extensively since they encapsulate current thinking about geographical education in South Africa.

2.6.1 THE SYLLABUS PREAMBLES

The preamble to the 1985 Revised Geography Syllabus, as adopted by the Cape and Transkei Education Departments, was unique in that it directed the teachers' attention to more than just changes in syllabus content (Van Harmelen, 1992). In detailing aims, objectives and teaching approaches, the preamble provides an insight into the participatory teaching strategies that have become a feature of school geography since the 1960s. This syllabus emphasizes the need for geographical education to develop conceptual understanding, skills, values and attitudes, and to provide opportunities which allow pupils to reflect, to analyse and to reason in approaching the study of their world and the problems and issues that face it. By identifying geographical education as being concerned with more than the acquisition of facts, this syllabus stresses the active participation of pupils in the learning process.

While there are certain differences in the introduction to the 1993 Draft Core Syllabus, this preamble essentially reflects the same goals of the 1985 Revised Syllabus. Similarly, the introduction to the 1993 Draft Core Syllabus urges teachers to encourage individual and group research techniques. The stress on greater pupil participation in the learning process and greater relevance to the needs of the society, as reflected in the stated aims of the above-mentioned geography syllabuses, indicates a shift in emphasis from teacher-directed approaches

to pupil-centred approaches in the teaching of geography. The four sets of objectives in these geography syllabuses are concerned primarily with knowledge, skills, perceptions and values. In both syllabuses emphasis is placed on conceptual and skill development and on the development of attitudes and values which will lead to the pupils' appreciation of the environment and an understanding of man's place in the environment. Teachers are encouraged to foster the pupils' abilities to think critically and analytically. The present geography syllabuses, therefore, are not merely concerned with what the pupils should learn, but with activities that are designed to facilitate the acquisition of knowledge.

An examination of the suggested teaching approaches in the 1985 Revised Syllabus and the 1993 Draft Core Syllabus provides guidance relating to the approaches which may be employed in the design and development of learner-centred tasks. The approaches included in the current syllabus are:

(i) A holistic approach, which emphasizes the interaction and relationships which exist between the various components of the geography syllabus. By implication this would include the interactions and relationships which exist in studies of the environment and the communities which form a part of the pupils' learning experiences.

(ii) Problem-solving and decision-making approaches which involve the pupil in critical thinking, problem identification, hypothesis formulation and hypothesis testing, and which encourage the pupil to move away from the purely descriptive task in the classroom.

(iii) Thematic approaches that are perceived as many strands which make up the reality of a particular environment, thereby increasing the pupils' spatial awareness. Studies related to themes involve the use of a diversity of materials and sources, which the pupil needs to analyse and evaluate.

(iv) Inter-disciplinary approaches which allow pupils to apply the skills they have acquired through geography to a multifaceted situation. By implication, studies such as these increase the pupils' perception of the relevance and value of the skills, concepts or values they have acquired through geography.

These approaches reveal how the design and development of learner-centred tasks may be varied to achieve a range of objectives and to provide pupils with a number of different learning experiences.

2.6.2 THE SYLLABUS CONTENT

An analysis of the content of the existing syllabuses in the four phases of geographical education reveals that the syllabus is broken down into a series of discrete topics or areas of study. In implementing these syllabuses the teacher tends to focus on each topic as a separate and discrete unit, thus giving rise to the compartmentalized nature of geography teaching. No deliberate effort is made to relate these topics to the aims, objectives and teaching approaches of the preamble, thus highlighting the dichotomy which exists between the preamble and the syllabus content.

The only attempt at environmental education or an environmental approach to education is via specific topics that teach **about** the environment. For example, in the Junior and Senior Primary Phases, children may learn about the homes of animals and aspects of their community. In the Junior Secondary Phase the pupils are required to recognize the need for conservation of nature, and in the Senior Secondary Phase ecology receives special mention. Emphasis is placed on ecosystems, environmental balance and conservation. This section, however, appears for the first time in the Std 10 syllabus and there is no direct reference to education **for** the environment as an approach to teaching.

A criticism that has been levelled at past Geography syllabuses has been the tendency to compartmentalize (Ledger,

1977; van der Merwe, 1982). It must often have appeared to pupils that their geography was a compendium of different subjects (GEOGRAM, 1993). A stark contrast to the dichotomy between the preamble and the content of the existing syllabuses is provided by a syllabus proposal for Stds 8, 9 and 10 by Nightingale (1993). This syllabus for the Senior Secondary Phase focuses attention on the theme of **sustainable development**. The theme of sustainable development will forge the link which ensures that the course forms a unified whole with the units complementing each other. More important, however, is the fact that the three years of study will convey an important message to the pupils.

The Core Modules have been selected to ensure that the pupils gain insight into the working of the natural and human systems of which they are part; and of the potential for good or ill of human management or mismanagement of the earth's resources. In Standard 8 emphasis is placed on the management of natural environments and on the use and misuse of natural resources. Water management has been mentioned as one of the core modules. In Std 9 attention is focused on the management of human environments and on issues of global concern. In Std 10 pupils are expected to study Africa - a continent in crisis - and South Africa at the crossroads. From these studies pupils are given an opportunity to explore and develop their own value systems. Thus the course becomes, in the best sense, a training in responsible citizenship.

2.7 RELATIONSHIP BETWEEN GEOGRAPHY SYLLABUSES AND THE ENVIRONMENTAL APPROACH

The preambles to the 1985 and 1993 geography syllabuses place an emphasis on the active participation of the learners, which is one of the features of education **for** the environment. The objectives of the syllabuses, which include the development of conceptual understanding and skills such as problem-solving and decision-making, are also in line with the current environmental approach. The 1985 Revised Geography Syllabus represented a major shift in geographical education and here, too, this syllabus may be related to education **for** the environment.

The participatory teaching strategies and the provision of opportunities for reflection, stressed in the 1985 and 1993 syllabuses, are in keeping with the tenets of education **for** the environment. However, with regard to the syllabus content, it must be spelt out again that specific topics still teach **about** the environment, and not **for** the environment. Topics emphasizing solutions to local environmental problems would be more worthwhile than those which recognize the need for conservation of natural resources.

This analysis highlights Walford's (1981) and Kelly's (1987) claim that although geography provides perspectives which are essential to environmental understanding and the framework within which environmental issues arise (Kelly, 1987),

geography teachers have been over-concerned with inculcating knowledge about the environment and too little involved in providing children with direct experience in the environment and with using the environment as a medium for learning skills which are related to sustainable living (Fien, 1993). The need for a greater emphasis on local environmental work in formal education demands and stimulates adaptations to traditional classroom approaches and practices.

Ironically, geographical education has a tradition of fieldwork which, if utilized as it is designed to be, will provide a methodology which can act as a springboard to education **for** the environment. Traditionally during fieldwork the students are required to collect and record data, to make field sketches and to share and rotate responsibilities among themselves. Current field research techniques such as those related to framework fieldwork (Boardman, 1986) move beyond observing and recording and encourage the development of skills necessary for environmental protection and improvement. A further feature of framework fieldwork is its recognition of the need for students to make decisions and judgements and to solve problems.

A key aspect of any approach to education is its perspective regarding knowledge and the acquisition of knowledge. The successful implementation of an approach to education is therefore largely dependent upon the extent to which the implementor understands the learning theory which underpins

the approach.

2.8 CONSTRUCTIVIST LEARNING THEORY UNDERPINNING THE IMPLEMENTATION OF AN ENVIRONMENTAL APPROACH

As environmental education theory has developed, so the learning theory which underpins it has developed. By the middle of the 1980s (Greenall, 1987; O'Donoghue and McNaught, 1989) environmental approaches had clearly begun to lean towards a constructivist approach to learning. However, just as environmental education theory is dynamic, so constructivism as a learning theory has not been static. An analysis of developments in constructivism is therefore useful in identifying the parallel movements in environmental education which have led to the notion of education **for** the environment.

The development of constructivist learning theory, and of different forms of constructivism which are distinguished by considering the basic principles and the underlying or assumed metaphors for the mind and the world, are discussed below.

2.8.1. FORMS OF CONSTRUCTIVISM

Von Glasersfeld (1989) distinguishes two forms of constructivism: information processing constructivism and radical constructivism.

2.8.1.1 Information processing constructivism

The first principle identified by von Glasersfeld as having led to information processing constructivism is the notion that "knowledge is not passively received but actively built up by the cognizing subject" (Glasersfeld, 1989: 182). This is largely based on the metaphor and sometimes the conscious model of the mind as a computer. The mind as computer actively processes information and data, calling up various routines and procedures, organizing the memorization and retrieval of data. The assumed metaphor for the world is that of absolute physical space populated by material objects. This is the world described by reason and science as unproblematic and knowable.

Information processing constructivism recognizes that knowing involves active processing, that it is individual and personal, and that it is based on previously acquired knowledge. Getting student teachers to realize this, by reflecting on error patterns in subjects or alternative conceptions, represents a significant step forward from the naive transmission view of teaching and learning.

2.8.1.2 Radical Constructivism

The second principle, which led to radical constructivism, is formulated as follows: "The function of cognition is adaptive and serves the organization of the experiential world, not the

discovery of ontological reality" (Glasersfeld, 1989: 182). Consequently, "from an explorer who is condemned to seek 'structural properties' of an inaccessible reality, the experiencing organism now turns into a builder of cognitive structures intended to solve such problems as the organism perceives or conceives" (Glasersfeld, 1989: 50).

The underlying metaphor for the mind or cognizing subject is that of an organism undergoing Darwinian evolution, with its central concept of the 'survival of the fittest'. This is also indicated in Piaget's notion of adaptation to the environment. According to the evolutionary metaphor the cognizing subject is a creature which generates cognitive schemas to guide its actions and represent its experiences. These are tested according to how well they 'fit' the world of its experience. The best 'fitting' of the schemas are tentatively adopted and retained as guides to action. The metaphor of the world is implicated in that of the mind. It is the cognizer's experiential world, rather like the environment surrounding an animal: experienced but not ultimately knowable.

2.8.1.3 Social Constructivism

Ernest (1991), along with other educational thinkers, has criticized the earlier forms of constructivism for neglecting the social dimensions of knowledge in learning. More recent constructivist theory has sought to rectify this shortcoming. Hence the term "social constructivism".

Social constructivism regards individual subjects and the realm of the social as interconnected. Human subjects are formed through their interactions with each other. Thus, there is no underlying metaphor for the isolated individual mind. Instead the metaphor of mind is that of persons in **conversation**, a metaphor which accords the mind a human status and recognizes that social and linguistic contexts are essential to the human nature of mind. Thus, the mind is seen as part of a broader context, the "social construction of meaning". The social constructivist model of the world is that of social reality, the socially constructed world which is created and constrained by the shared experience of the underlying physical and social worlds.

As a parallel development to social constructivism there have been increasing calls for a socially critical environmental education (Huckle, 1991; Fien, 1993; Greenall, Gough and Robottom, 1993). Kemmis (1986, in Greenall, Gough and Robottom, 1993: 301) has described socially critical schooling as intending "to provide students with a map of existing culture and society and a map of what a better society might be like". This map is only possible where social reality is constructed by the shared experience of the learners. Greenall, Gough and Robottom (1993: 301) maintain that, like socially critical education, environmental education is concerned with a "critical understanding of, and an informed commitment to, the improvement of society".

Social theorists have introduced the process of **reflexivity** which is described as "cultural reconstruction through critical social processes of experiential review" (O'Donoghue, 1993: 37). Significant features of reflexivity include, first, the recognition of the value of different forms of knowledge and, second, dialogue and negotiation between them (Beck, 1992).

The need to consider environmental issues within the context of social, historical, political, economic and biophysical factors has been recognized. These dimensions of the environment are outlined in the following diagram.

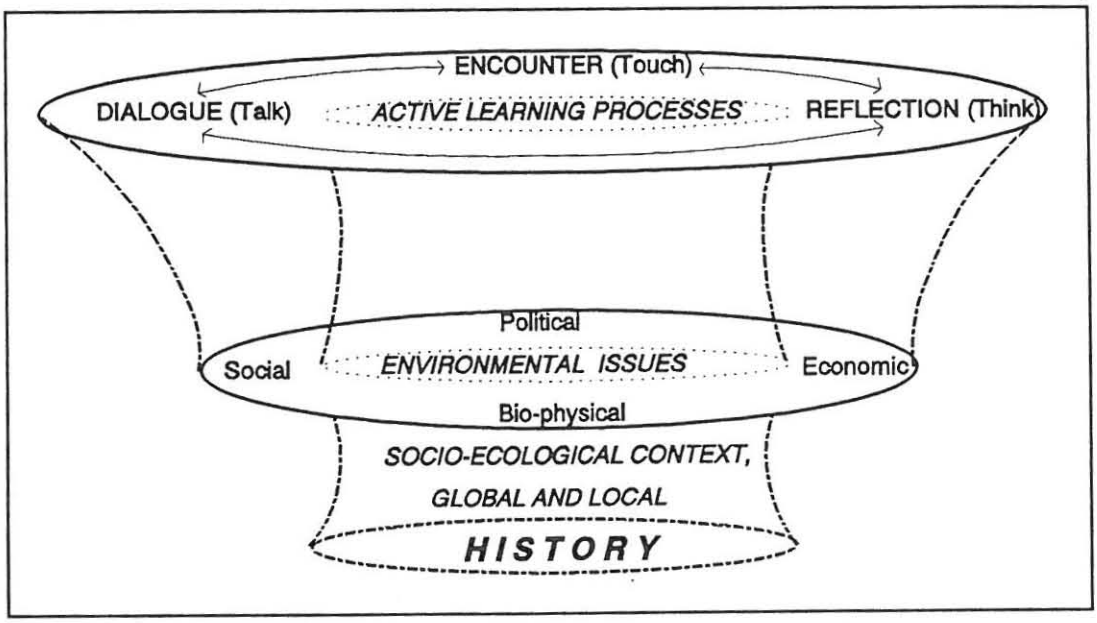

FIGURE 2.2 Meaningful contexts and issues for active learning (O'Donoghue et al., in press).

From the above diagram it is evident that a more holistic view of environmental problems has been taken and their social aspects have been considered. This view addresses the problems both of treating the environment merely as a physical world and of the individualization of the causes of, and solutions to, environmental problems.

When we refer to an environmental approach in the light of current theory, we are referring to a socially critical approach to education which is based on social constructivism. This approach is closely linked to Unwin's (1992) idea of how people have created their environments and why these environments cannot be separated from their human construction which has resulted in the formation of "places".

> Place has become a focus for understanding the interaction of the human world of experience and the physical world of existence. The task of a critical geography is to enable people to reflect upon this interaction, and in so doing create a new and better world (Unwin, 1992, 210).

If geography educators are to adopt an environmental approach to the teaching of geography which emphasizes education for the environment, then geography too will need to be located within social constructivism and socially critical learning theories. This will mean a shift in emphasis from teaching **about** the environment to teaching and learning which is based upon the criteria identified earlier. One of the aspects which becomes important in geography teaching is active empowerment through community-based and-integrated environmental projects.

If geography can be taught from an environmental point of view it can contribute to the solution of environmental problems. In achieving the aims of environmental education, particularly as defined by current environmental educational theory, we are achieving the aims of geography; and conversely, if we teach geography in the light of the ecological paradigm which underpins the 1985 syllabus, we are achieving the aims of environmental education.

The strength of geography as a discipline will be maintained only if education **for** the environment is adopted as an approach to geography. If human geography is to be subsumed within a broadly defined social science, and physical geography within the earth sciences, it is difficult to sustain an argument for the survival of anything resembling geography. It is against this background that an attempt to promote the use of the current environmental approach in the teaching of geography is made at Transkei College of Education.

2.9 SUMMARY

This chapter explores paradigm shifts in both environmental education and geography and examines the relationship between the aims, approaches and learning theory of environmental education and geography. A critique of some conventional approaches to environmental education and geography is followed by a description of a socially critical learning theory which underpins the implementation of an environmental approach. A shift in emphasis from top-down messages to participatory action, from early 'nature experience' approaches to broader experiential or action learning, and from the conservation of natural resources to sustainability and social justice, is portrayed.

Although similarities have been identified between the aims, principles and learning theory of environmental education and geography, it is evident that what is lacking in geography teaching is the use of an environmental approach which promotes both societal and student action towards environmental sustainability.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The primary purpose of this study was to promote student teachers' understanding of an environmental approach to the teaching of geography, more specifically, of an approach which emphasizes education **for** the environment. In order to achieve this goal, the research was completed in a series of phases.

The first phase was the identification of water management as an appropriate topic to be used to demonstrate the application of an environmental approach in the teaching of geography and to introduce the essential concepts needed for an understanding of this topic as an environmental issue.

The second phase involved identifying the student teachers' understanding of the concepts introduced in the course of phase one. This was done through an open-ended test which formed the first stage of the Treagust and Haslam (1987) two-tier test discussed in this chapter.

The third phase involved the planning and implementation of the teaching unit. This phase incorporated a variety of teaching strategies such as role play, and the collaborative development of worksheets and fieldwork. Interviews were also employed.

The fourth phase assessed both the success of the teaching approach and the students' understanding of the approach, as well as their conceptual understanding of the essential concepts underpinning the topic chosen as the focus of the study. This stage employed the second phase of the Treagust two-tier test and summative evaluation instruments. Formative evaluation techniques were used throughout the study.

This chapter will analyse the above phases, procedures and instruments within the naturalistic research paradigm that was adopted. Furthermore, the research sample, data analysis and limitations of the study will be examined.

3.2 ACTION RESEARCH

The methodology employed in this study was that of action research within the naturalistic paradigm. Guba and Lincoln (1988) distinguish two main research paradigms in education. The first is the rationalistic paradigm, which is modelled on the natural sciences and emphasizes empirical quantifiable observations which lend themselves to analyses by means of mathematical tools. The other paradigm is naturalistic and is derived from the humanities, with an emphasis on holistic and qualitative information and on interpretative approaches.

The naturalistic paradigm differs from the rationalistic paradigm in that it:

(a) assumes that multiple realities exist, which are constructions existing in the minds of people. These constructions are intangible and can be studied only in a holistic fashion.

(b) assumes that enquiry is not value-free but value-laden.

(c) prefers humans as instruments to non-human devices, for reasons such as their greater insightfulness, flexibility and responsiveness.

(d) does not insist on a priori formulations of theory before entering the field. The naturalist anticipates that the design will emerge or unfold as the enquiry proceeds, with each step heavily dependent on all preceding steps.

(e) prefers natural settings instead of laboratory conditions. The naturalists argue that only in nature can one discover what does happen rather than what can happen. Moreover, studies in nature can be transferred to other similar contexts, whereas laboratory studies can be generalized only to other laboratories.

The following definition, characteristics, advantages and disadvantantages of action research as associated with the naturalistic paradigm form a background to the justification of this methodology for the study.

3.2.1 Definition

According to Hopkins (1985) action research combines an act with a research procedure; it is action disciplined by enquiry, a personal attempt at understanding whilst engaged in a process of improvement and reform.

The following definition taken from Kemmis (1983), has been selected for the purpose of this study.

> Put simply action research is the way groups of people can organize the conditions under which they can learn from their own experience ... Action research is trying out an idea in practice with a view to improving or changing something, trying to have a real effect on the situation.

This definition has been selected because it focuses on group interaction, learning from experience and the practical improvement of real problems, which are all factors characteristic of this study. In keeping with the naturalistic paradigm this definition places emphasis on human beings as valuable instruments for research in a natural setting.

3.2.2 Characteristics

Action research was developed by Kurt Lewin in the post-war period as a method of intervention into social problems (Lewin, 1946). In line with Kurt Lewin's idea, this study represents an intervention by the researcher in a practical teaching situation to improve the teaching of geography

through a variety of teaching strategies. Kemmis (1983) regards "practice" as the strategic action undertaken with commitment in response to a practical problem. This study therefore, represents a practical response to an identified practical problem of water pollution and mismanagement.

Action research is described as "participatory" since team members and individuals undertaking it participate directly or indirectly in its implementation (Kemmis, 1983; Dane, 1990; Cohen and Manion, 1989). This study can also be described as participatory in nature since:

(i) The researcher with her colleagues identified the problem to be studied in relation to its appropriateness.

(ii) The researcher, her colleagues and the student teachers, participated directly in the development, implementation and evaluation of the teaching unit.

Any study conducted through action research can be evaluated and modified continuously as it progresses so as to improve the practice under consideration. Such a method is described as a "self-reflective spiral of cycles of planning, acting, observing and reflecting" (Kemmis, 1983; Walker, 1985; Cohen and Manion, 1989). This was also characteristic of the present study. While the researcher, her colleagues and student teachers were developing and implementing their teaching unit, they were involved in observing, evaluating, re-planning and acting according to the results of such evaluation.

3.2.3 Advantages

Consideration of the following advantages led the researcher to adopt the methodology of action research in this study:

1. Action research stimulates change and improvement within the educational situation in which it occurs (Kemmis, 1983; Hustler et al., 1986).

2. It is one of the methods in which all parties involved are allowed to behave naturally (Mcniff, 1988).

3. Action research ensures positive and active pupil involvement in a process which provides them with opportunities for greater educational growth.

4. One of the most important advantages of action research is its adaptability and flexibility. The study can be modified and adapted as it progresses (Walker, 1985; Cohen and Manion, 1989).

3.2.4 Disadvantages

Action research is frequently challenged as being subjective and therefore unreliable (Mcniff, 1988). The validity of the research is reduced by the fact that the solutions it claims to generate cannot be universally tested. Validity refers to the extent to which the results of a given piece of research can be accurately interpreted and universally tested and

applied. Reliability is the consistency of the research and the extent to which two or more researchers studying the same setting or subjects come up with the same findings (Bodgan and Biklen, 1982). Subjectivity in action research can, however, be reduced and validity and reliability can be increased through evaluation (Keeves, 1988).

Evaluation refers to a process aimed at providing information about the value or worth of a programme or strategy (Keeves, 1988). Evaluation in action research is more effective if it is done at every stage or level. Action research therefore favours the use of formative evaluation which provides information for improvement, modification and management.

However, there are many methods of formative evaluation. For the purpose of this study responsive evaluation was selected. This form of evaluation lies within the naturalistic paradigm which helps to understand people and the meanings behind their activities. It promotes participant observation by using observers to describe the natural human processes and responses of those involved (Williams, 1986; Guba and Lincoln, 1988).

In participant observation the researcher is perceived as the main tool of investigation and his/her primary strategy is being with the subjects in their natural life setting (Ball, 1988). Responsive evaluation rests on the notion that the truth of the researcher's analysis and its validity can be

ascertained by establishing some degree of correspondence between the researcher's and the subjects' views of the activities undertaken and/or the setting under study (Ball, 1988). In this study, forms of respondent evaluation were used as a way of improving validity and reliability.

3.3 RESEARCH SAMPLE CHARACTERISTICS

According to Cohen and Manion (1989), a sample is the population upon which the survey focuses attention. Such a sample enables one to collect information from a smaller group or subset of the population in such a way that the knowledge gained is representative of the total population under study.

The sample used in this study consisted of 50 third-year secondary school geography specialists at Transkei College of Education. This sample size is appropriate for the purpose of the study, which is to promote the use of an environmental approach in the teaching of geography. It is best suited for action research, which may be pursued by a single teacher operating on her own with her class and feeling the need for some kind of change in teaching or learning. It is also appropriate for the purposes of action research, which are to equip the teacher with new skills and teaching methods, to remedy problems diagnosed in specific situations, and to inject innovatory approaches to teaching and learning into an ongoing system which normally inhibits innovation and change (Cohen and Manion, 1989).

The researcher used non-probability sampling, which is a sample in which the probability of selection of each respondent is known (Cates, 1985). Despite the disadvantages that arise from their non-representativeness, non-probability samples are far less complicated to set up, are comparatively less expensive, and can prove perfectly adequate where the researcher does not intend to generalize her findings beyond the sample in question. The type of non-probability sampling chosen was that of purposive sampling, which is a sample in which the researcher handpicks the cases to be included in the sample on the basis of her judgement of their typicality. In this way she builds up a sample that is satisfactory to her specific needs (Cohen and Manion, 1989).

The researcher chose this type of sampling because her aim was to promote the understanding, on the part of a sample group of geography student teachers, of an environmental approach in the teaching of geography. The disadvantages arising from the non-representativeness of non-probability samples, therefore, did not affect this study, since the aim of the study was not to generalize the findings.

3.4 THE RESEARCH INSTRUMENTS USED IN THE STUDY

In the course of the various phases of the action research a variety of techniques was used to gather data. Included amongst these techniques were the interviews, the Treagust and Haslam (1987) two-tier test, observation schedules and

summative evaluation schedules. These instruments are analysed and justified below.

3.4.1 THE TWO-TIER TEST

Having identified water management as an appropriate focus for the action research it was necessary to identify the students' conceptual understanding of this topic. It was for this reason that a two-tier test, developed by Treagust and Haslam (1987), was adapted.

The two-tier test is a multiple-choice test. The first tier is related to propositional statements derived from an open-ended pencil-and-paper test (Treagust and Haslam, 1987). The second tier consists of a multiple-choice set of reasons. It must be emphasized that the Treagust and Haslam two-tier multiple-choice test is not an ordinary objective multiple-choice test. It is a particular test for a particular problem. Its aim is to diagnose students' misconceptions about a particular issue to be studied.

In developing this test, a series of concepts were identified which were considered to be essential foundations upon which the rest of the project could be developed and built. In line with constructivist learning theory, the students' perspectives on these concepts were identified by means of open-ended questions. The students were also required to give reasons for their answers. Thus, the students' answers to the

open-ended questions form the first tier of the Treagust and Haslam (1987) test.

This test was piloted by means of two studies which were undertaken in a small class of second-year geography specialists in June 1993. During the first pilot study the student teachers were required to respond to open-discussion interviews and to answer open-ended questions. After the student teachers had evaluated the questions, the open-ended test which is included in this study was shortened and improved. The second pilot study involved cross-referencing of the types of student responses with the questions asked in the first pilot study. The responses finally provided the focus for the development and refinement of the two-tier multiple-choice instrument.

The open-ended questions were answered in writing by 50 third-year student teachers in July 1993 (Appendix 1). The advantage of open-ended questions is that they provide opportunities for gathering a great variety of data. The disadvantage is that the examiner is required to weigh a variety of evidence, a task which calls for substantial amounts of personal judgement. As a result, different examiners usually arrive at different scores for the same answer, and hence this type of assessment is not regarded as objective.

The open-ended test was best suited for this study because the aim was to get a variety of wrong answers which would be used

as distracters in a two-tier multiple-choice test rather than to get correct answers. The great variation in the responses that are produced even among students of similar ability or attainment, associated with open-ended tests, was exactly what was required for the purpose of this study.

One may be surprised, as the researcher has been, by the absurdness of some of the student teachers' responses. No matter how absurd the distracters are, they do represent the learners' conceptual understanding prior to a teaching intervention.

The second tier consists of a multiple-choice set of reasons for the answer given in the first tier. The set of reasons, which are based on the students' responses to open-ended questions, consist of identified misconceptions and a scientifically acceptable answer. Spaces are also provided in test answer sheets for students to provide reasons which are different from the reasons provided in each of the 10 items.

All the student teachers who wrote an open-ended test were required to write the two-tier multiple-choice test (Appendix 2) at the beginning of October 1993.

Several studies (Doran, 1972; Linke and Venz, 1978, 1979; Halloum and Hestenes, 1985) have shown that a reliable and valid multiple-choice diagnostic test, incorporating students' reasons as alternative responses, minimizes guessing and encourages honest responses.

3.4.2 INTERVIEWS

In the course of this study interviews were used for a number of purposes:

1. The researcher used informal interviews as part of the formative and summative evaluation of the study. These interviews were conducted with students to clarify their perspectives at various stages in the study.

2. Secondly, interviews with a group of residents from a rural settlement were used as stimulus material for classroom discussion. These interviews were semi-structured.

3. Interviews were also used by the students as part of their data gathering in the course of the problem-solving activity in which they were engaged. These interviews were structured. Therefore it can be seen that in this study interviews were used not only for data collection but also as a teaching strategy within the environmental approach adopted.

According to Cohen and Manion (1989), a research interview is a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information. The interviewer focuses on content specified by the research objectives of systematic description, prediction or explanation. The interview also involves the gathering of data

through verbal interaction between individuals.

In terms of design, interviews may be structured, semi-structured or unstructured. In structured interviews set questions are asked and the answers are recorded on a standardized schedule. The main advantage of a structured interview is its uniformity of measurement which leads to greater reliability. The main disadvantage is that the interviewer has no freedom to do anything except nod and make "neutral noises" (Burroughs, 1971: 103).

In semi-structured interviews the researcher poses predetermined questions but has considerable flexibility concerning follow-up questions. The main advantage of semi-structured interviews is that they are less formal; the interviewer is free to modify the sequence of questions, change wording, explain questions or add to the questions; the interviewer can also probe for more specific answers to clarify and eradicate any misunderstanding (Cohen and Manion, 1989). While the flexibility of semi-structured interviews is an advantage it can also be a disadvantage in that not every respondent is asked the same questions, thus reducing validity (Dane, 1990).

In unstructured interviews, the researcher encourages the respondent to discuss a topic but provides little or no guidance and very few direct questions. The main disadvantage of these interviews is that responses are idiosyncratic and

make it difficult to analyse data obtained. The main advantage is that the respondent is given freedom and the interviewer can probe in order to elaborate on particular responses (Dane, 1990).

3.4.3 THE OBSERVATION AND SUMMATIVE EVALUATION SCHEDULES

Croll (1986:1) defines "observation" as a process whereby observation is done through a systematic set of rules devised for recording and classifying events. The most commonly used procedure for conducting systematic observation is that of live observation by the non-participant observer (Croll, 1986).

The advantages of live observation include the following factors:

1. The observer is generally unobtrusive in the learning situation.
2. Such observation capitalizes on the flexibility of the individual observer.
3. Observers, furthermore, can easily switch attention between different individuals or different events.
4. A single observer can adapt rapidly to respond to what is going on (Croll, 1986).

This type of observation does, however, have disadvantages which include the fact that:

1. the nature of the observation is limited by the requirements that it must be possible for an observer to observe and record simultaneously, thus limiting the complexity of observation (Croll, 1986);

2. observation is a slow process which can only deal with a small and non-random sample;

3. it is expensive of skills and time, as the individual observer often cannot spend much time, nor is able to travel long distances, which the topic may often demand (Burroughs, 1971).

The focus of the observation used for this study was on the extent to which the environmental approach was implemented in the study and on the development of skills necessary for sustainable living. During the fieldwork phase the researcher observed the student teachers' involvement in field activities, their interaction and discussion, and their interest and enthusiasm.

At the end of the study the non-participant observer and the students used summative evaluation schedules which incorporated the 5 point Likert scale, which enabled them to assign a numerical value to their descriptions. The use of the numerical value helps to remove part of the subjectivity which

occurs when individuals describe events (Croll, 1986).

3.5 VALIDITY AND RELIABILITY OF THE INSTRUMENTS

The researcher was continuously aware of the problems of validity and reliability in terms of the research instruments used. The discussion below considers attempts made to reduce this problem where possible.

In order to increase the reliability and validity of the study "triangulation" was used. Triangulation involves the use of two or more methods of data collection in studying aspects of human behaviour. Triangulation may also be achieved through the use of more than one observer.

According to Cohen and Manion (1989) triangulation has the following advantages:

1. The use of different methods of data collection increase the confidence in the reliability and validity of the data, as exclusive reliance on one method may distort the researcher's picture of the particular reality under investigation.

2. Triangulation techniques provide flexibility which increases reliability since many data-collecting methods are made possible.

3. Triangulation utilizes either normative or interpretive techniques or it draws on methods from both these approaches and combines them.

The triangulation used in this study incorporated the use of a variety of instruments such as interviews, fieldwork, open-ended and two-tier tests. It also incorporated the use of evaluation by a variety of people. The above instruments were scrutinized by the supervisor, colleagues, student teachers and the non-participant observer, who is a lecturer in the Department of Education at the University of Transkei. She has extensive experience in teaching and, moreover, she has been involved in research encouraging the use of fieldwork in geography and the use of the local environment as a resource.

3.6 DATA COLLECTION AND ANALYSIS

1. Data relating to the student teachers' conceptual understanding of water management as an environmental issue was collected through the administration of an open-ended test before the teaching unit was taught and the administration of the two-tier test at the end of the teaching unit. The results of these tests were quantitatively and qualitatively analysed. The test scores were classified and presented in tables using percentages. The scores of the two tests were compared and the percentage improvement for each item was calculated. The percentage improvement illuminated the extent to which the

teaching unit based on the environmental approach was effective in improving the conceptual understanding of the student teachers. With reference to the tables, the overall understanding of the concepts was presented qualitatively through the analysis of, and general comments on, the performance of student teachers in both tests.

2. Data gathered in the course of the teaching unit was qualitatively analysed by the researcher.

3. The observation schedule used by the non-participant observer used a 5-point Likert scale. The results of that were analysed and interpreted in terms of the adjectives used in the key.

4. The students' evaluation questionnaire similarly used a 5-point Likert scale. Collected data was presented in the form of percentages and tables. These were then described, analysed and interpreted.

3.7 RESEARCH PROCEDURES AND PHASES

The study was completed in the following four phases:

3.7.1 PHASE 1: IDENTIFICATION OF THE TOPIC AND THE ESSENTIAL CONCEPTS

The first phase involved the identification of water management as an appropriate topic to demonstrate the

application of an environmental approach to the teaching of geography. The topic on water management was selected from the geography syllabus because the availability of fresh water is a major environmental issue in Transkei and widespread droughts have focused attention on the need for careful management of fresh water resources.

Having chosen water management as an appropriate topic the next part of this phase was to identify the essential concepts needed for an understanding of this topic as an environmental issue. The identification of the essential concepts related to water management was carried out with the assistance of the supervisor and college lecturers. Working collaboratively is encouraged by education for the environment because collective action is usually more productive than individual efforts.

3.7.2 PHASE 2: IDENTIFICATION OF THE STUDENTS' CONCEPTUAL UNDERSTANDING OF WATER MANAGEMENT

The learning theory embedded within education for the environment requires an exploration of the learners' prior knowledge before an attempt is made to provide new information on the issue to be studied. For this reason this phase of the research was designed to identify the students' conceptual understanding of the issue that would be studied in the field. This was done by means of the two-tier test as discussed previously.

3.7.3 PHASE 3: THE DEVELOPMENT AND IMPLEMENTATION OF THE TEACHING UNIT

The teaching unit was developed in line with the notion of education for the environment (Fien, 1993) and was structured according to the criteria identified as guidelines for the adoption of an environmental approach to the teaching of geography (Chapter 2).

In the course of the teaching unit a variety of teaching strategies were involved. These included a collaborative learning exercise, a simulation game and role play, student conducted interviews, water quality tests, a map exercise and field research. Each of these teaching strategies will be discussed more fully in Chapter 5.

These teaching strategies were chosen because of their ability to involve students in participatory learning leading to critical thinking and problem solving, which is central to the environmental approach adopted (Chapter 2).

The teaching unit consisted of a number of phases which included a pre-planning phase, field research and feedback. The pre-planning phase involved responses to the letters written by the researcher asking for the Catchment Action Starter Kit (Appendices 3, 4 and 5), the development of the essential concepts through participatory activities, and the training of the students in techniques that would be

necessary for fieldwork. Field research was conducted at two test sites (Fig. 5.1). The feedback was effected through the administration of the two-tier test and evaluation. Throughout this process the students' participation was emphasized.

3.7.4 PHASE 4: EVALUATION PROCESSES AND PROCEDURES

The teaching unit in this study was evaluated by a variety of people. Firstly, there was self-evaluation which was effected through participant observation by the researcher. Everything that was deemed relevant to the purpose of the study was recorded by the researcher, the main emphasis being placed on interpretation of the behaviour and responses of the students during the whole interaction process.

Secondly, there was peer evaluation by college lecturers and a non-participant observer. A non-participant observer is an "observer who does not participate in the development and implementation of activities at the setting. He or she looks at the scene, literally or figuratively, through a one-way mirror" (Bodgan and Biklen, 1982: 127). The non-participant observer used observation schedules (Appendix 10) which were developed by the researcher with the non-participant observer. The observation schedules were scrutinized by colleagues prior to their implementation.

Thirdly, there was learner evaluation. Student evaluation forms (Appendix 11) were prepared and improved through the

involvement and comments of colleagues. The 5-point Likert scale was also used in the students' evaluation forms. In using the three instruments for evaluation it was recognized that "all reports of social phenomena require a degree of intersubjectivity between the researcher, the subject and the audience (non-participant observer) for the research" (Croll, 1986: 8).

The evaluation of the teaching unit was both formative and summative in the sense that the student teachers were required to evaluate each and every phase of the teaching unit verbally and in the end they were required to evaluate the whole teaching unit through the use of evaluation forms.

3.8 LIMITATIONS OF THE STUDY

The following are perceived as the limitations of the study:

1. The limited time that the researcher was able to spend with the student teachers proved to be the major limitation to the study. The session during which the study was conducted was marked by interruptions caused by the SADTU strikes. The interruptions were in the form of class boycotts which made it impossible for the researcher to complete her planned activities within the scheduled time.

It was even more difficult to deal with third-year student teachers who felt that the strikes were levelling ground for them as they would be qualified teachers the following year.

When the second phase of the fieldwork was completed, at the end of September, the student teachers were already preparing for their examinations. Consequently, the field unit that was planned to take place after the findings of the first and the second units had been compiled (phase 3), could not be implemented and evaluated as time had to be given to the administration of the two-tier multiple-choice test. The researcher was compelled to take this decision since it was not possible to give the two-tier test to another group of students who had not previously been exposed to the open-ended questions.

The time for the follow-up had to be kept to a minimum. The follow-up was seen to be most rewarding as it involved problem-solving strategies and community involvement. It also required each group of the student teachers to select a topic from the current Junior Secondary School geography syllabus and to develop a teaching unit and teaching materials, using an environmental approach to geography. Thus more time would have increased the benefits.

2. Although the absence of the non-participant observer in some of the activities with the student teachers was not a major problem, it did mean that the use of triangulation was limited. The non-participant observer was fully employed and she had to supervise her own student teachers who were out on teaching practice. Like the researcher, she had to make use of the little time that was available as the assessment rate of her own student teachers was also affected by the SADTU strikes.

3.9 SUMMARY

This study was primarily based on the process of promoting student teachers' understanding of the currently accepted environmental approach to the teaching of geography. The local environment (Umtata river) was used as a resource for fieldwork. This was achieved through action research.

Data collection was done by means of interviews, open-ended and two-tier tests and through field visits. The results of open-ended questions were compared with those of the two-tier test in an attempt to evaluate the effectiveness of the teaching unit which was based on the use of an environmental approach. Validity and reliability were ensured through triangulation. The analysis of data based on the methodology discussed above will be presented in Chapters four and six.

CHAPTER FOUR

AN IDENTIFICATION OF STUDENT TEACHERS' CONCEPTUAL UNDERSTANDING THROUGH OPEN-ENDED QUESTIONS

4.1 INTRODUCTION

As indicated in Chapter 3 the rationale for setting the open-ended test was to identify the students' conceptual understanding of water management. Conceptual understanding is seen as a vital prerequisite for the development of the sort of knowledge required for education **for** the environment. The essential concepts identified for the preliminary understanding of water management as an environmental issue included the following: the hydrological cycle, catchment management, human impact, renewable and non-renewable resources, water supply and demand, water pollution, chemical balance of water, water conservation and environmental sustainability.

4.2 THE STRUCTURE OF THE OPEN-ENDED TEST

The student teachers were required to answer open-ended questions which were based on the above concepts. They had to provide reasons for their answers. To ensure that the questions were applicable and appropriate, a pilot study was undertaken in a small class of second-year geography specialists. After the questions had been evaluated the test

was shortened and improved with regard to the structure of the questions and language usage to eradicate ambiguities. The results discussed below refer to the responses of student teachers to the open-ended test which is included in this study (Appendix 1).

4.3 OPEN-ENDED QUESTION RESULTS

A great variety of data was gathered through the use of open-ended questions which were based on the prior identification of concepts. The great variation in the responses is reflected in tables throughout this chapter.

4.3.1 THE ROLE OF THE HYDROLOGICAL CYCLE

The first question in the test attempted to find out if the students understood the role played by the hydrological cycle in terms of water supply.The answers to this question are reflected in the table below.

Table 4.1 : The Role of the Hydrological Cycle

	No. of students	%
Correct answer	16.0	32.0
Did not answer the question	11.0	22.0
Helps plants grow	9.0	18.0
Purifies water	5.0	10.0
Supplies water during drought	4.0	8.0
Takes water from full rivers and gives it to dry rivers	2.0	4.0
Have never fetched water from the hydrological cycle	2.0	4.0
Rain is provided by God only	1.0	2.0
Total	50.0	100.0

The examination of data relating to the student teachers' understanding of the role played by the hydrological cycle in maintaining the balance between water usage and water replenishment indicates that 50 per cent of them have little or no understanding of the concept "hydrological cycle". The above findings are deduced from the fact that about 22 per cent of the students did not attempt to answer the question and 28 per cent of them gave wrong answers which include the following: the hydrological cycle takes water from full rivers and gives it to dry rivers; it purifies water; it supplies people with water even during drought periods, and so on.

About 9 per cent of the wrong answers given were related to the indication by some of the student teachers that "they had never been sent by their parents to fetch water from the hydrological cycle, instead they had been sent to fetch it from the river or tap", and 4 per cent of the wrong answers attributed the provision of rain to the Supernatural powers. These misconceptions showed that the student teachers were not sure about the the role of the hydrological cycle in terms of water supply.

Surprised by the unexpected absurdness of some of the answers from the third-year geography specialists, the researcher interviewed 5 student teachers in an attempt to find out the reasons underlying such serious misconceptions. The interviews illuminated that some of the geography teachers who taught the student teachers from standards 8 to 10 did not like the

section on climatology. This section provides the basic understanding of processes such as evaporation, condensation and precipitation which are related to the hydrological cycle.

The structure of the Std 10 final examination question paper also provides an opportunity for those teachers who "do not like" the section on climatology, not to teach it. The question paper allows students to choose one question from Section A whilst this section is composed of two questions; one question on climatology and one question on geomorphology.

Almost 18 per cent of the student teachers related the role of the water cycle to plant growth. (Table 4.1). Only 32 per cent of them seemed to have a good understanding of the role of the hydrological cycle. These students related it to the processes of evaporation, condensation and precipitation, and explained how these processes maintain the balance between water usage and water replenishment.

4.3.2 MANAGEMENT OF THE RIVER'S CATCHMENT AREA

The answers relating to the question on the necessity of catchment management are shown in Table 4.2.

Table 4.2 : Catchment Management

	No. of students	%
Where river originates (mountain)	18.0	36.0
Where tributaries join main stream	9.0	18.0
Where stream piracy occurs	8.0	16.0
Where river meets the sea	7.0	14.0
Where sediments are deposited during floods	5.0	10.0
Did not answer the question	3.0	6.0
Total	50.0	100.0

The majority of answers as to whether it was necessary to manage the catchment area of a river or not, reflected a serious deficiency in the student teachers' grasp of the concept of the catchment area. About 14 per cent of them described the catchment area as the region at which the river meets the sea. According to them, it would be fruitless to manage this area since the river is already polluted and useless to the communities.

Whilst 18 per cent of the student teachers maintained that catchment management would necessitate the prevention of water from joining the main stream as the catchment area is the point at which the tributaries join the main stream, 16 per cent claimed that it would be difficult and expensive to manage the catchment area since it is where stream piracy occurs. Almost 10 per cent of them defined the catchment area as the place where the river deposits its sediments during floods and about 6 per cent of them did not attempt to answer the question.

From the above discussion it is evident that almost 64 per cent of the student teachers did not understand the meaning of the catchment area (Table 4.2). Only 36 per cent of them described it as the source or origin of the river. This group suggested that water pollution, soil creep and siltation should be prevented by not allowing human settlement in and near the catchment area.

The misconceptions relating to the catchment area were attributed to the fact that the majority of geography teachers did not use visual aids and fieldwork. The student teachers mentioned the problem of language as one of the factors which affect their conceptual understanding. They stated that as second-language speakers they experience difficulty in understanding the concepts through the use of definitions only. For examination purposes they rely on rote learning without any understanding. They further pointed out that if they had previously been involved in fieldwork and model-building activities they would have performed better in the test.

4.3.3 THE HUMAN IMPACT ON WATER RESOURCES

The responses with regard to the nature of human impact on water resources are reflected in Table 4.3. The answers were classified according to those who regarded the impact as positive, negative or non-existent.

Table 4.3 : The Human Impact on Water Resources

	No. of students	%
Positive Impact		
Many people will purify water	5.0	10.0
Negative Impact		
Scarcity of water	22.0	44.0
Increased water pollution	16.0	32.0
No Impact		
Water is stored in many large dams	4.0	8.0
Water is non-perishable	3.0	6.0
Did not answer the question	0.0	0.0
Total	50.0	100.0

Only a small percentage (10 %) of the student teachers maintained that the increasing human population will have a positive impact on water resources (Table 4.3). This group claimed that many people will assist in the purification of water. The majority of student teachers (76%) mentioned negative effects which included the following: scarcity of water because the more the people, the greater the use of water, and increased water pollution as more waste, including factory effluent, will be thrown into rivers. About 14 per cent of them claimed that the increasing human population will have no impact at all because water is non-perishable and many dams have been built on South African rivers to store water.

Better performance on this question was attributed to the popularity amongst geography teachers of the section on the effects of population explosion in the Std 8 geography

syllabus. Furthermore, television programmes such as "Ecovision" were mentioned as being effective in conveying the message about the adverse effects of increasing population numbers.

4.3.4 WATER AS A RENEWABLE OR NON-RENEWABLE RESOURCE

The fourth question aimed at finding out whether water was perceived as a renewable or non-renewable resource by the student teachers. The reasons given to support the answers are summarized in Table 4.4.

Table 4.4 : Water as a renewable or non-renewable resource

	No. of students	%
Renewable:		
Can be purified	8.0	16.0
Can be renewed through the hydrological cycle	8.0	16.0
Can be drilled from underground	7.0	14.0
Can be stored in dams	4.0	8.0
Non-renewable:		
Cannot be manufactured by factories	12.0	24.0
No rain, no water	9.0	18.0
Water is non-living	2.0	4.0
Total	50.0	100.0

Although 54 per cent of the student teachers regarded water as a renewable resource (Table 4.4), some of the reasons given to support this were not satisfactory. For example about 14 per cent of them stated that water is renewable because it can be drilled from underground and 8 per cent claimed that it is renewable because it can be stored in dams. Almost 16 per cent of them maintained that it can be purified and used again whilst another 16 per cent attributed its renewal to the hydrological cycle.

About 46 per cent of the student teachers regarded water as a non-renewable resource. Almost 24 per cent pointed out that water is non-renewable because it cannot be manufactured by the factories and 18 per cent stated that it if there is no rain there would be no water. A small percentage (4 %) claimed that water, like minerals, is non-living and therefore cannot be replenished.

4.3.5 THE SECTOR THAT MAKES THE GREATEST DEMAND ON WATER SUPPLY

Table 4.5 shows variation in the answers with regard to the sector of the economy which makes the greatest demand on the water supply in Umtata.

Table 4.5 : Sector Making the Greatest Demand on the Water Supply in Umtata

	No. of students	%
Industry	22.0	44.0
Agriculture	14.0	28.0
Municipality	9.0	18.0
CBD	5.0	10.0
Total	50.0	100.0

An examination of data relating to the sector of the economy which makes the greatest demand on the water supply in Umtata, indicated that the municipality and the CBD were perceived to be economic sectors by 28 per cent of the student teachers (Table 4.5). They attributed the greatest demand on water supply to the municipality's responsibility to distribute water in the townships and to the fact that most people have left the rural areas for the town.

About 44 per cent of them mentioned the industrial sector as the sector that makes the greatest demand and explained that it needs water for generating electricity and for manufacturing and cooling purposes. Almost 28 per cent of the student teachers pointed out that agriculture makes the greatest demand on the water supply as crop cultivation needs great amounts of water for irrigation purposes.

4.3.6 THE SECTOR THAT IS MOST RESPONSIBLE FOR WATER POLLUTION

The responses relating to the question on the sector of the economy which is most responsible for water pollution in Umtata are shown in Table 4.6.

Table 4.6: Sector Most Responsible for Water Pollution in Umtata

	No. of students	%
Industry	19.0	38.0
Agriculture	12.0	24.0
Residential Areas	10.0	20.0
CBD	9.0	18.0
Total	50.0	100.0

About 38 per cent of the student teachers believed that the industrial sector is most responsible for water pollution in Umtata because oil and chemicals from manufactured products are drained into the river and pollute water. Almost 64 per cent of those who related the greatest demand on the water supply to the CBD and the municipality in Table 4.5 maintained that the CBD was most responsible for water pollution since the population density is high and the rate of water pollution is increasing with population growth.

About 24 per cent of the answers indicated that agriculture was most responsible for water pollution because poisonous pesticides from the irrigated lands are washed into the river by heavy rainfall, whilst 20 per cent attributed water pollution in Umtata to the residential areas as sewage and dirty water from the baths flows into the Umtata river.

4.3.7 THE MOST DETRIMENTAL FORM OF WATER POLLUTION

Differences of opinion relating to the form of water pollution which is regarded as most detrimental to water purity in Umtata are reflected in the following table.

Table 4.7 : Form of Water Pollution that is most Detrimental to Water Purity in Umtata

	No. of students	%
Factory effluent	20.0	40.0
Littering	12.0	24.0
Sewage	9.0	18.0
Soap froth from household washing	9.0	18.0
Total	50.0	100.0

Factory effluent was believed to be most detrimental to water purity in Umtata by 40 per cent of the student teachers (Table 4.7). They pointed out that factory effluent is poisonous because it consists of oil and chemicals. About 24 per cent of them regarded littering as most detrimental to water purity

since it is washed into the river when heavy rain falls. Almost 18 per cent of them stated that sewage is most detrimental to water purity because it is difficult to purify. Soap froth from household washing was perceived to be most detrimental by 18 per cent of the student teachers. They pointed out that it cannot even be used for irrigation purposes.

4.3.8 RELATIONSHIP BETWEEN WATER POLLUTION AND CHEMICAL BALANCE (pH) OF WATER

The eighth question attempted to identify the student teachers' conceptual understanding of the relationship between water pollution and the chemical balance (pH) of water. The answers given by the student teachers are summarized in Table 4.8.

Table 4.8 : Relationship between Water Pollution and the Chemical Balance (pH) of Water

	No. of students	%
Did not attempt to answer the question	41.0	82.0
The pH of healthy rivers ranges between 4 and 6	3.0	6.0
Rain water is naturally slightly acidic	3.0	6.0
The pH of 7 indicates massive pollution	2.0	4.0
Sewage and industrial effluent affect the pH balance of water	1.0	2.0
Total	50.0	100.0

The majority of the answers as to whether there is any relationship between water pollution and the chemical balance (pH) of water or not, indicated that 98 per cent of the student teachers had little understanding of the meaning of the term "chemical balance". About 16 per cent of them gave the following wrong answers:

There is a relationship because the pH of healthy rivers ranges between 4 and 6; there is no relationship because rain water is naturally slightly acidic; sometimes a relationship occurs, for example, if the pH is 7 it indicates massive pollution. Almost 82 per cent of the student teachers did not even attempt to answer the question. Only 2 per cent of them came up with an acceptable statement which is: Sewage and industrial effluent discharges affect the pH balance of water.

4.3.9 WATER CONSERVATION IN SOUTH AFRICA

The following table contains answers to the question which attempts to find out whether there is a need for water conservation in South Africa or not. The reasons for the answers given are also provided.

Table 4.9 : The Need for Water Conservation in South Africa

	No. of students	%
Need for water conservation		
Limited rainfall	15.0	30.0
Frequent droughts	14.0	28.0
Limited water resources	7.0	14.0
Dependence of South Africa's economy on water	5.0	10.0
Uncertain		
RSA has lots of underground water	3.0	6.0
RSA is not a desert	3.0	6.0
RSA has large dams	2.0	4.0
No need for water conservation		
God will always provide us with rain	1.0	2.0
Total	50.0	100.0

The majority of the student teachers (82%) recognized the need for water conservation in South Africa (Table 4.9). Their reasons in support of water conservation included the following:

South Africa's average rainfall is less than 500 mm a year and is not regular; there are frequent droughts; South Africa's economy depends on water and water resources are limited.

About 16 per cent of them were uncertain whether there was a need for water conservation or not. They pointed out that South Africa is not a desert and there are other parts of the world that are drier than South Africa. They also stated that South Africa has large dams and lots of underground water. A small percentage (2%) mantained that there was no need to conserve water because God will always provide us with rain.

4.3.10 WATER RESOURCES AND ENVIRONMENTAL SUSTAINABILITY

The responses in the following table reflect the student teachers' conceptual understanding of environmental sustainability in relation to the use of water resources.

Table 4.10 : Use of Water Resources for Environmental Sustainability

	No. of students	%
Little or no understanding		
There must be enough water for purification	9.0	18.0
Nothing should be done	8.0	16.0
Flush toilet hundred times	4.0	8.0
Good understanding		
Complain and take action	14.0	28.0
Collect rain water	9.0	18.0
Use a shower only	4.0	8.0
Place brick in cistern of the toilet	2.0	4.0
Total	50.0	100.0

An examination of data relating to whether there is a need to use water resources for environmental sustainability or not, indicated that about 42 per cent of the student teachers did not understand what is meant by "environmental sustainability" (Table 4.10). This was evident from their suggestions which included the following:

Use a shower and a bath so that there can be enough water for purification; nothing should be done because it is the duty of those responsible for water pollution to take action; toilets can be flushed as many times as we like because small amounts of water are wasted when flushing them.

Those who understood what was meant by "environmental sustainability" (58%) gave the following suggestions:

Use a shower rather than a bath because baths can use five to ten times more than a shower; complain to businesses, factories or farmers if you see them polluting rivers or wasting water, and conduct litter cleanups; flushing toilets wastes huge amounts of water. If you have a flush toilet place a brick in the water tank to reduce the amount of water used; encourage people to collect rain water from their roofs in containers because this can be used for gardening and other purposes.

4.4 SUMMARY

From the above analysis it is evident that student teachers specializing in geography at Transkei College of Education have serious misconceptions with regard to water pollution and water management as an environmental issue. The reasons underlying such misconceptions include the following:

1. Some geography teachers ignore certain sections of the geography syllabus, thereby depriving students of the necessary basic conceptual knowledge.

2. Students with language problems have to rely on rote learning and subsequently do not understand definitions of concepts.

3. Most geography teachers do not use learner-centred teaching strategies which enhance students' conceptual understanding, e.g. fieldwork and model building.

The absurdness of the answers from student teachers is a great cause for concern because their misconceptions can be transferred easily to the pupils during their teaching if no remedial work is done at the colleges of education. Furthermore, these misconceptions can hinder any form of action. It is not possible to solve environmental problems if sufficient knowledge about those problems has not been acquired. If action is to be taken, there must be adequate acquisition of knowledge and conceptual understanding. Since

education **for** the environment promotes action needed for environmental protection and improvement, the need for conceptual understanding and development is great.

It is against this background that the diagnosed misconceptions outlined above led to the development of the teaching unit which used an environmental approach on water pollution and water management. The aim of the teaching unit was to eradicate misconceptions so that action towards the solution of water pollution problems could be taken.The details of the teaching unit are presented in Chapter 5.

CHAPTER FIVE

THE TEACHING UNIT

5.1 INTRODUCTION

The teaching unit discussed in this chapter was designed to investigate the extent to which the use of an environmental approach to the teaching of water management as a local environmental issue would achieve the aims of both geographical and environmental education. The first stage of an environmental approach discussed in Chapter 4 proved how important it is to establish the learners' prior knowledge before embarking on the development of new knowledge. The teaching unit was developed in order to demonstrate the use of an environmental approach and to eradicate the misconceptions identified in the previous chapter. An environmental approach is identified by the criteria (Chapter 2) in Table 5.1 below.

In this chapter the teaching unit is described as it was developed and taught. In the course of the discussion the methodology which underpins an environmental approach as discussed in Chapter 2, will be applied and evaluated. The organization of the chapter follows the development of the teaching unit. Thus section 1 deals with the conceptual development necessary for the understanding of the issue to be dealt with, and section 2 focuses attention on fieldwork which was used as a strategy both to enhance the students'

conceptual development and to involve them through practice in reaching solutions and deciding on a plan of action. Each stage also reflects formative evaluation as it occurred throughout the implementation of the teaching unit. The third section, which deals with the summative evaluation, involves not only the implementation of the environmental approach in the teaching unit but also evaluation of an environmental approach as a teaching approach. The manner in which the teaching unit as a whole was evaluated is also described in this chapter.

Table 5.1 The criteria necessary for an environmental approach to geographical education

An environmental approach to education should:

* examine social, political, economic, historical and biophysical factors and their interrelationships and interdependence.
* be participatory and practice-based. Learning experiences through which people may play a part in making their society a better place in which to live, should be provided.
* be enquiry-based so that current beliefs and practices may be regarded as problematic, as open to self- and peer-analysis and critique, and as having the potential for improvement through participant research.
* provide opportunities for critical thinking so that participants can be empowered to make appropriate changes to achieve geographical and environmental education objectives they favour.
* provide opportunities for the development of problem-solving skills necessary for the improvement of the quality and sustainability of natural and social environments.
* promote conceptualization and conceptual development rather than factual recall.
* be collaborative because collective action is usually more productive than individual efforts.
* be community based and involve participants in the active investigation and resolution of real world problems of relevance to the communities in which they live.

5.2. CONCEPTUAL DEVELOPMENT AS A PRELIMINARY TO EDUCATION FOR ACTION

The very fact that the open-ended test revealed such a severe lack of knowledge gave direction to the researcher in the role of teacher, in terms of the teaching strategies to be used. The researcher was aware that shared understanding may be acquired through shared experience and active participation in the learning process. The students could have been given definitions for memorization. This, however, would be contrary to social constructivist learning theory which is at the heart of education for the environment. The researcher therefore felt that the most appropriate teaching strategies for the students' conceptual development were the following: a co-operative learning exercise, interviews conducted by the students, a simulation game and role playing.

5.2.1 A CO-OPERATIVE LEARNING EXERCISE

The student teachers were divided into five groups of ten and were given the opportunity to construct their own meaning of the concepts pertaining to the hydrological cycle and the catchment area of the river by using library resources. On the basis of their reading, each group had to bring a picture or a model or a diagram of the hydrological cycle and the catchment area of the river which would act as a stimulus to further discussion. At the end of the discussion each group leader explained the processes involved in the hydrological cycle,

using the group's teaching aid. Group leaders were also expected to identify the features of the catchment area and explain what happens in the catchment area when precipitation occurs. Group members had to assist their leader in responding to questions from other groups.

At the end of this discussion the researcher distributed documents on the relationship between water pollution and the chemical balance (pH) of water (Appendix 6) for group discussion. The same procedure was followed.

The co-operative learning exercise worked well in that the discussions were lively and challenging. The students were responsive; the meaning of the concepts emerged through negotiation which culminated in shared understanding. During this process the researcher was the facilitator. The students who previously had misconceptions with regard to the hydrological cycle, the catchment area of the river, and the relationship between water pollution and the chemical balance (pH) of water were given an opportunity to develop an understanding of the concepts which far exceeded their understanding had they simply worked as individuals or had they simply been taught the definitions through the transmission mode. The level of this understanding will become evident as the study progresses. The use of visual aids also enhanced their conceptual understanding as they were allowed to pose questions, argue and critically evaluate the teaching aids in terms of their applicability and accuracy.

5.2.2 THE SIMULATION GAME AND ROLE PLAYING

It was felt that certain concepts such as renewable and non-renewable resources, the impact of the increasing human population on water resources and the maintenance of environmental sustainability, would be better developed through strategies other than the collaborative group exercise used for the previous concepts. For that reason the researcher decided to use a simulation game and role playing to demonstrate the effect of the increasing human population on water resources. The game involved the staging of a have or have-not situation and was designed to extrapolate the concepts as a result of the interaction in the course of the game. The interaction provided an opportunity for the discussion of possible ways of conserving water and for the discussion of whether water was renewable or non-renewable. The simulation game and role playing also enabled the role players to realize the need to use water resources in order to maintain environmental sustainability. Suggestions as to why and how water resources should be used in a manner that could sustain the environment also emanated from the various groups.

The use of a simulation game and role playing stimulated the learning of the relationship between overpopulation and water resources. The students were interested and motivated. The game was kept simple and the students entered into its spirit very quickly. They displayed real human feelings which helped to develop empathy. A further benefit of this activity is that

the students' involvement in simulation and gaming activities was developed to a high degree.

5.2.3 INTERVIEWS

There was uncertainty about the sector of the economy which makes the greatest demand on the water supply in Umtata and the sector which is most responsible for water pollution. Because the project was based on real problems the researcher felt that the students needed to be exposed to the sorts of channels and resources within the community that could be utilized in the resolution of such problems. For this reason it was felt that for these particular concepts the best source of information would be the municipal authorities. Therefore the researcher contacted the town clerk and in collaboration with him agreed on a series of interviews by the students. The student teachers drew up appropriate interview schedules and made appointments for the interviews with the town clerk. In the course of these interviews the students suggested that it would be useful to obtain documentary proof from him, about the form of water pollution that is most detrimental to water purity in Umtata. Four of the groups managed to interview the town clerk. The fifth group could not get hold of him, and instead interviewed one of the municipal officials.

The student teachers were exposed to this type of data for the first time and their research skills were developed. They felt that this was a worthwhile exercise. They expressed their

appreciation of the town clerk's warmth and willingness to be interviewed. They also realized that members of the community can be co-operative if the interviews are conducted in a respectful and peaceful manner. The success of these interviews encouraged the students to become more involved in community projects.

The use of models, pictures, simulation games, role-playing, interviews and group discussions provided an opportunity for the students' conceptual development through active participation. The researcher did not tell the students what the meaning of the concepts were, instead she acted as a facilitator.

Having reached this stage, the students, in the researcher's opinion, were competent and confident enough to move into the next stage which was education for action.

5.3 EDUCATION FOR ACTION: THE DEVELOPMENT OF FIELDWORK AS AN APPROPRIATE STRATEGY

The students were aware that the preliminary phase was an introduction to the investigation of a real issue in their local community, that of water management in the Umtata river. In preparing for the investigation of this problem the researcher with her students formulated a set of procedures which would be adopted to investigate and resolve the problem. The students suggested that before anything could be done a

reconnaissance of the area should be undertaken.

The intention was to make an exploratory trip along the entire course of the Umtata river which would give the students an understanding of the physical landscape and of the communities and their concerns along the course of the river. This exploratory reconnaissance would then direct the investigation. Time constraints and disruptions caused by SADTU strikes rendered it impossible for the students to undertake this exploratory investigation. With the agreement of the students the researcher undertook the initial exploration of the study area.

The preliminary investigation involved the researcher in consulting the relevant 1:50 000 maps covering the course of the Umtata river. The researcher travelled along the course by car and identified one community of particular interest in that they were notably affected by water pollution. The community lives in a rural settlement called Orange Grove which is situated some 5 km down river from the city of Umtata (Fig. 5.1). In the course of her reconnaissance the researcher interviewed a group of 8 residents of Orange Grove using a tape recorder. The intention was to bring the interviews into the classroom so that they could serve as stimulus material for class discussion.

5.3.1 USE OF STIMULUS MATERIAL

After listening to the interviews the student teachers were made aware of the fact that the residents of Orange Grove were complaining about the polluted water they were compelled to use. The residents spelled out the effects of water pollution on their children's health. They also made it clear that they had no option but to use polluted water since most of them cannot afford to buy water tanks.

The recordings as a stimulus worked particularly well for the following reasons:

(i) The student teachers who were from the rural areas in other parts of Transkei pointed out that they were experiencing the same problem in their homes and were interested to see this problem being solved so that they could apply the same problem-solving strategies when they went back to their homes.

(ii) The following questions emerged as a result of the group discussions:

1. How can we be sure that water is really polluted in Orange Grove? Should we rely on what we hear from the tape recorder?

2. If water is polluted in the Umtata river what factors are responsible for its pollution?

3. How can we try to solve the problem of water pollution in Orange Grove?

On the basis of these questions the students suggested how the investigation should proceed. Fieldwork was identified as the most appropriate strategy for the investigation. The students felt that fieldwork should be conducted in order to:

1. Test water in the catchment area and in Orange Grove. The two samples were to be compared so that it could be established if there was, in reality, water pollution in Orange Grove.

2. Investigate the causes of water pollution along the course of the river.

3. Interview the town clerk and other people responsible for water pollution and approach the residents of Orange Grove so that they could act jointly with the students in demanding the implementation of water management strategies in the Umtata river.

What was noteworthy was the high degree of relevance and sophistication of the students' suggestions. The researcher believes that this was made possible because of the students' conceptual development and because of the previous teaching strategies that had been employed.

Since the student teachers were not involved in undertaking a reconnaissance of the river the first planning stage for fieldwork aimed at familiarizing them with the course of the Umtata river through map exercises.

5.3.2 MAP EXERCISES

The facilitator distributed the following topographic maps amongst them:

3128AD UMNGA FLATS
3128BC MJIKA
3128DA VIEDGESVILLE and
3128DB UMTATA.

Using the 1:50 000 topographic maps the student teachers were required to trace and isolate the features listed below using different shadings for each feature:

(i) The catchment area
(ii) The course of the Umtata river
(iii) Human activities (e.g. farming) that are taking place along the course of the river
(iv) The direction of flow of the Umtata river
(v) Both urban and rural settlements including Orange Grove.

These tracings were combined and reduced to provide a single field map (Fig. 5.1). This map was used to suggest river quality test sites. It was decided that site A on the map should be the catchment area and site B should be Orange Grove.

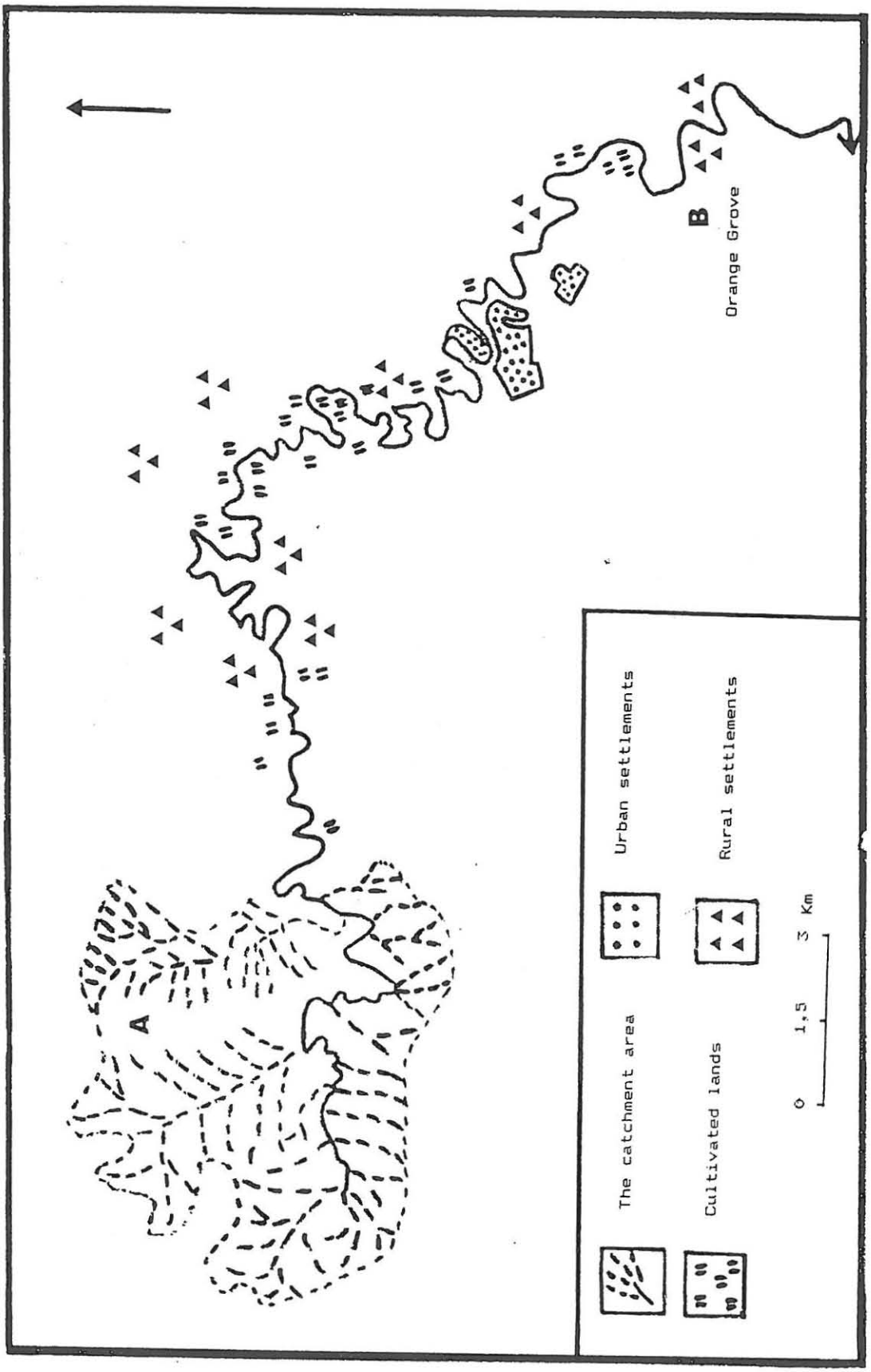

Figure 5.1 Human Activities in the Catchment Area and along the Course of the Umtata River

The student teachers managed to draw the above features and use the maps effectively because of their conceptual development and prior training in mapwork. The students were active and not only were their cartographic skills developed but they were actively involved in the planning and selection of sites to be visited. The student teachers' verbal evaluation of this stage also confirmed their understanding of the problem-solving strategy in which they were engaged.

5.3.3 WATER TEST PROCEDURES

Since the student teachers had to be familiar with water test procedures before going in the field it was necessary to deal with the procedures in the classroom.

Working in groups the student teachers were required to bring water samples in small bottles, into the classroom. Water samples had to be obtained from different sources. The first test was on the chemical balance (pH) of water. The pH sticks, paper-packed pH strips and colour codes were supplied to each group. The student teachers were required to dip the pH sticks into water samples for about 15 minutes or until a colour change had taken place. After comparing the dip stick with the colour code they were able to read-off the pH value and record their results on horizontal bar graphs which showed the relationship between the pH and water pollution (Appendix 6).

The second test was on chemical enrichment (nitrates) of water. The same procedures discussed above were followed for the second test but nitrate sticks were used instead of pH sticks. After comparing nitrate sticks with colour codes the chemical enrichment could be read and recorded on the horizontal bar graph which reflected the relationship between water pollution and chemical enrichment (Appendix 7).
The findings of each group were discussed in class.

"To do in order to understand" lies at the heart of an environmental approach. By conducting water quality tests student teachers came to understand the relationship between water pollution and concepts such as chemical balance (pH) and chemical enrichment of water. From the students' verbal evaluation of this procedure, it was evident that their conceptual understanding with regard to the chemical balance and chemical enrichment of water had been improved.

5.3.4 CONSTRUCTION AND DEVELOPMENT OF WORKSHEETS

The fourth preparatory stage was the development of the worksheets for use in the field. The student teachers remained in their groups. Each group was required to construct two worksheets on charts. One worksheet was for the catchment area of Umtata river (site A) and another one was for the course of the river and Orange Grove (site B). All the charts with the worksheets for site A were pasted on the chalkboard and the questions were compared. The best questions in terms

of appropriateness were selected from the five groups and modified. In other words the worksheets were discussed, analysed and evaluated. One student teacher wrote the refined questions on a separate chart. The same procedure was followed for the second worksheet (i.e. for site B). Both worksheets are included in this study as appendices 8 and 9.

The construction, development and use of worksheets developed the students' observation and recording skills and encouraged active participation. The questions were appropriate and the students developed critical thinking skills. During the construction and development of worksheets the researcher swapped roles. Instead of being the facilitator she acted as a co-learner.

During the planning phase which included the use of the interviews, the map exercise, the preparation for water testing and the development of the worksheets, the researcher noted the following aspects which need highlighting:

1. The students' level of competence within a set of participatory teaching strategies was raised. The students developed as critical thinkers and problem solvers.

2. A wide range of skills and values was developed. Not only cognitive skills were developed but also the following:

   (a) Geographical skills such as cartography and recording of data on the worksheets.

(b) Environmental skills, e.g. problem-solving.

(c) Social skills, e.g. team work and leadership skills.

The development of these skills is evident in the development of worksheets which are the culmination of the whole series of processes. These worksheets were an early indication to the researcher of the students' understanding of how to apply an environmental approach in the teaching of geography.

Providing the opportunities described above for the students in order to develop their conceptual understanding through active participation in the learning process proved to be not only worthwhile but also exciting, in that the researcher was surprised and delighted by the extent and depth of the students' conceptual and skill development.

This series of activities highlighted the value of the role of the teacher as a facilitator and a co-learner and emphasized the fact that effective teaching does not depend on a transmission mode. A further benefit to the researcher was the realization that learners, given the opportunities, are capable of taking responsibility for their own learning.

Two further points need to be mentioned.

1. The students as prospective teachers were exposed to a real learning and teaching situation which encapsulated a critical thinking approach within their peer group.

2. Each student teacher was exposed to the implementation of a variety of teaching strategies in practice. All of these strategies are participatory and collaborative and thus central to Fien's (1993) notion of an approach to education for the environment.

5.3.5 FIELDWORK PHASE

The implementation of the fieldwork units was determined by the three questions raised by the student teachers in the pre-fieldwork phase. It was decided that fieldwork should be conducted in the following three phases:

PHASE 1 : A VISIT TO THE CATCHMENT AREA OF THE UMTATA RIVER

The first phase involved a visit to the catchment area of the Umtata river (site A, fig. 5.1). The student teachers had to remain in their respective groups in order to discuss the data collected in the field. The non-participant observer joined the group during this phase of the study.

Two tests for water pollution were conducted and the student teachers recorded their findings on the worksheets. An emphasis on the worksheets was to draw diagrams and describe the catchment area with regard to its suitability in terms of water management.

The catchment area was described as undulating and covered with forest. A few rural settlements such as Mangweni, Mbolompo and Gqogqora were observed (Fig. 5.1). The residents of these settlements cultivate small plots of land which are along the river banks. The area is relatively free of litter. Water tests in the catchment area revealed that the chemical balance was normal (7,5) and its chemical enrichment ranged from 0 to 10mg/1 (ie. enriched) (Table 5.1). The visit to the catchment area included an investigation of the river adjacent to the water test site. Thus it was found that a few kilometres from the catchment area (downstream), at Langeni forest (Fig. 5.1), there is a chipboard factory which disposes of its used water straight into the river. Langeni forest was regarded as the starting point of water pollution of the Umtata river.

The responses to the worksheets reflected that the primary source of water in the catchment area is precipitation rather than underground water. The suggestions with regard to the protection of the catchment area included fencing, construction of dams and prohibition of human settlement and economic activities which would lead to accelerated erosion and pollution by pesticides and insecticides. The responses to the worksheets also stressed the need to use water sparingly at our homes by not leaving open taps unattended. It was suggested that water purification measures should be undertaken by the economic sectors. Generally the need for water conservation in Umtata was realized.

From the student teachers' evaluation of this first phase it was apparent that fieldwork was successful in enhancing their conceptual understanding and skill development. The only problem which was encountered was the inaccessibility of some parts of the catchment area due to the thick natural vegetation (forest).

It is worth mentioning that although at first the need for visiting the lower course of the river was realized, the researcher and the student teachers were compelled to forego this visit owing to limitations of time. This was not a major problem because the two fieldwork phases were sufficient to enable the researcher and her students to compare the findings and to demonstrate the use of an environmental approach through fieldwork.

PHASE 2 : A VISIT TO THE MIDDLE COURSE OF THE UMTATA RIVER

The middle course of the Umtata river on which the rural settlement of Orange Grove is situated (Fig. 5.1) was visited during the second phase. In contrast to the area first visited the students noted that the area was severely polluted by litter, sewage, animal and human faeces, waste water from households, factory effluent, dead animals and soil erosion. Water tests were conducted and the findings recorded. The student teachers were encouraged to discuss their findings in their respective groups before recording them.

It was found that along this part of the Umtata river the rural communities lack adequate toilet facilities. Although water purification measures are undertaken in one sewage disposal work, nothing has been done about sewage from Corana location (Fig. 5.1) above the Orange Grove settlement. Sewage from this location is channelled straight into the Umtata river. Water quality tests also revealed pollution problems in Orange Grove which are presented in Table 5.1 below (site B).

Table 5.2 : Water Quality

	Chemical Balance (pH)	Chemical Enrichment (nitrates)
Site A:	7,5 - Normal	0 - 10mg/1 - enriched
Site B:	5 - Highly polluted	10 -20mg/1 -polluted

The problems of water management and water purity which occur at Orange Grove are exercerbated by the use of water in the city of Umtata. Here the students established that the greatest demand on the water supply of the town is made by the industrial sector. This sector is also guilty of the most pollution as factory effluent is allowed to run into the river. Therefore the inhabitants of Orange Grove have to contend with water pollution from up river and the pollution caused by the unsatisfactory state of services in the village.

The fieldwork experiences provided the data and the incentives which formed the basis on which the students could develop their plan of action to resolve the problem of water management in this region. The field experiences had the following benefits:

1. The student teachers could use the data gathering tools and could analyse and reflect on the data. This was confirmed by the students themselves when they stated that during this phase they were so used to recording and water test procedures that they took less time to do the activities than during the first phase.

2. They could work collaboratively.

3. They understood the use of fieldwork as a teaching strategy.

The students were exposed to an appropriate strategy for the gathering of information which could lead to action and make it possible to find solutions to real problems. Thus, the students were not doing a meaningless exercise but were using fieldwork as a vehicle for the resolution of problems rather than as an end in itself. This emphasizes the way in which the adoption of an environmental approach to geography is able to shift the emphasis from teaching about the environment and in the environment, to teaching for the environment.

5.3.6 PHASE 3 : POST FIELDWORK PHASE: A PLAN OF ACTION

Having identified certain problems in the Umtata river the student teachers suggested a plan of action (Rehabilitation Plan). The following problem-solving strategies emerged from their group discussions.

1. Conduct litter cleanups
2. Improve waste management
3. Donga reclamation
4. Build better toilets
5. Improve health education (i.e. promote the use of household chemicals to purify water).

The observations and findings were compiled into a short report. It was decided that both the findings and the recommendations should be made known to the town clerk in order to get his support and to encourage action. The residents of Orange Grove were to be informed as well so that they could work jointly with the student teachers in trying to solve water pollution problems. However, the limited time available made it impossible to implement the above decision. It was towards the end of September and the student teachers were already preparing for the examinations. The result was that phase three was planned but not implemented.

The fact that the student teachers could develop a plan of action although it could not be implemented is an indication

of the fact that they had understood what is meant by **education for the environment.** Problem-solving strategies, action and community involvement in the protection and improvement of the environment, discussed above, is the focus of education **for** the environment - the key to addressing environmental problems. A plan of action, therefore, was in consonant with the socially critical learning theory which has gained popularity in recent years.

The researcher had hoped that the final stage of this phase would involve a debriefing session which would lead to the selection of a topic from the current Junior Secondary School geography syllabus, and to the development of a teaching unit and teaching materials, using an environmental approach in geography. The aim in this final stage was to provide opportunities for the student teachers to apply an environmental approach to the various topics of the geography syllabus.

The time constraints made it impossible to follow up on the student teachers' projects. Even the students themselves confessed that although they were willing to do the project, they had to prepare for the examinations. In their evaluation, however, the students assured the researcher that they would be able to develop their own teaching units.

Given more time, the development and evaluation of the student teachers' units would have been fruitful since it was the

intention of this study to ensure that the student teachers would be able to use this approach in their schools after they have graduated from the college. The student teachers' teaching units would be of benefit to other geography teachers as they could serve as guidelines, after their improvement and compilation, for teaching particular topics in geography.

5.4 SUMMATIVE EVALUATION OF THE TEACHING UNIT

The focus of evaluation in this study was the worth of the teaching unit in terms of using an environmental approach and the worth of an environmental approach as a teaching approach. The teaching unit was evaluated by a variety of people. Firstly, there was self-evaluation which was effected through participant observation by the researcher. Everything that was deemed relevant to the purpose of the study was recorded by the researcher, the main emphasis being placed on interpretation of the behaviour and responses of the student teachers during the whole interaction process.

Secondly, there was peer evaluation which was effected through college lecturers and the non-participant observer. The non-participant observer used observation schedules (Appendix 10) which were formulated by the researcher and scrutinized by colleagues prior to their implementation.

Thirdly, there was learner evaluation. Student teachers were required to evaluate each and every phase of the teaching unit verbally. In other words, evaluation was formative as it took place as an on-going process throughout the teaching unit. In the end the student teachers were required to evaluate the whole teaching unit through the use of evaluation forms (Appendix 11).

The rest of this chapter presents the evaluation of the teaching unit, in terms of its use of an environmental approach, by the researcher, the non-participant observer and the student teachers. Attention is also focused on the researcher's evaluation of an environmental approach as a teaching approach.

5.4.1 Evaluation by the student teachers

More than 80 per cent of the student teachers indicated that participation from the beginning to the end of the teaching unit was excellent. It is worth noting that all the student teachers felt that the teaching unit had helped them to develop lifestyles for sustainable use of water resources and an informed concern for the environment.

All the student teachers pointed out that the teaching unit had helped them to develop the following skills to a great extent: observation, identification, recording, associating, communication, decision making and problem solving.

About 50 per cent of the student teachers described the opportunity provided by the teaching unit to explore and solve environmental issues as satisfactory whilst 12 per cent of them described it as weak. This feeling may be ascribed to the fact that the problem of water pollution was explored but not solved in reality. The third phase of fieldwork which aimed at community involvement and joint solution was planned but not implemented. The student teachers did not get the opportunity to meet the residents of Orange Grove. This may be why the question on the opportunity given by the teaching unit to interact with other people in the solution of environmental problems was described as weak by 18 per cent of them, whilst 72 per cent felt that it was only satisfactory (Table 5.3).

The fact that more than 80 per cent of the student teachers described the consideration of both social and biophysical factors in the teaching unit as good, reflected a shift of the teaching unit from nature experience approaches to broader experiential or action learning. This shift was confirmed by more than 80 per cent of the student teachers who described the shift towards action learning and local co-operative and participatory action as excellent. The extent to which the teaching unit promoted environmental sustainability was described as good by 70 per cent of the student teachers.

It is significant to note that all the student teachers felt that the teaching unit enhanced their understanding of an environmental approach which was the main aim of this study.

Furthermore, about 80 per cent of them maintained that the teaching unit was excellent in helping them to improve their conceptual understanding.

All the student teachers stated that fieldwork was interesting to them and more than 50 per cent of them regarded the actual fieldwork as most interesting. The majority of the student teachers pointed out that the fieldwork was most effective, most rewarding, most practical and easiest to understand.

Again it is worth noting that all the student teachers found no part of the teaching unit boring and hard to understand. More than 50 per cent of them, however, felt that the preparation was difficult as they were expected to draw accurate maps and understand scientific water test procedures before going into the field.

TABLE 5.3 STUDENT TEACHERS' EVALUATION OF THE USE OF AN ENVIRONMENTAL APPROACH IN THE TEACHING UNIT

(Scores in percentages)

PART ONE:	1	2	3	4	5
1. The extent to which the teaching unit gave you an opportunity to:					
(a) Participate actively from the beginning to the end of the unit				15	85
(b) Develop an informed concern for the environment			8	30	62
(c) Develop lifestyles for sustainable use of water resources			9	17	74
(d) Develop skills			5	9	86
(e) Explore and try to solve an environmental issue		12	50	38	
(f) Consider both social as well as biophysical factors			12	88	
(g) To interact with other people in the solution of environmental problems		18	72	10	
2. Shift in emphasis of the unit from:					
(a) Top-down messages to local co-operative and participatory action				15	85
(b) Nature experience approaches to action learning			8	10	82
(c) Conservation of natural resources to sustainability			24	70	6
3. The extent to which the teaching unit:					
(a) Improved your conceptual understanding				14	86
(b) Enhanced your understanding of an environmental approach			12	10	78

TABLE 5.3 (CONTINUED)

(Scores in percentages)

PART TWO:		1	2	3	4	5
1.	**Part of the fieldwork (preparation, actual fieldwork and follow up) found**					
1.1	most interesting		44	56		
1.2	most effective		38	62		
1.3	most boring	100				
1.4	most rewarding			88	12	
1.5	easiest to understand			100		
1.6	most practical		16	84		
1.7	hardest to understand	100				
1.8	most difficult?	46	54			

KEY:

PART ONE

1 - Very weak
2 - Weak
3 - Satisfactory
4 - Good
5 - Excellent

PART TWO

1 - None
2 - Preparation
3 - Field excursion
4 - Follow up

5.4.2 Evaluation by the non-participant observer

The student teachers' involvement in activities, their interaction and discussion, and their interest and enthusiasm were described as good by the non-participant observer. Their development of all skills was described as good except their ability to draw field sketches which was described as weak.

Opportunities provided by the teaching unit for active participation, for exploration and resolution of an environmental issue, for consideration of social as well as biophysical factors and for social interaction were described as excellent. The development of an informed concern for the environment, the promotion of lifestyles for sustainable use of water resources and the development of skills in the teaching unit were described as good. The shift in emphasis of the teaching unit from top-down messages to local co-operative and participatory action, from nature experience approaches to action learning, and from conservation of natural resources to sustainability, was also described as good. In the non-participant observer's opinion, the effectiveness of the teaching unit in the improvement of students' conceptual understanding and in the enhancement of the students' understanding of an environmental approach was good.

In evaluating the whole teaching unit the non-participant observer described it as participatory, as promoting action and environmental sustainability. In other words, it was

successful in meeting the requirements of an environmental approach.

5.4.3 Evaluation by the researcher

The researcher was involved in participant observation, in the evaluation of the teaching unit in terms of using the environmental approach, as well as in the evaluation of an environmental approach as the teaching approach. The evaluation of the teaching unit in terms of using an environmental approach will not be repeated in this section since it has already been presented in different phases of the teaching unit (5.3.1; 5.3.2; 5.3.3; 5.3.4; 5.3.5).

Participant Observation

1. The student teachers' responses in the first test (i.e. open-ended test) revealed that their ability to respond correctly and clearly was hampered by their poor command of English.

2. During the fieldwork phase, the student teachers experienced no problems in using the water kit after some initial training during the preparation phase.

3. In the field the student teachers showed great enthusiasm and excitement. The greatest enthusiasm was, however, evoked by the water quality tests which revealed student

teachers' ability to make decisions as they had to decide on the readings of colour codes and colour changes on both pH and nitrate sticks.

4. Field sketches of the catchment area revealed that some of the student teachers' drawing skills were poorly developed. However, some of the field sketches were satisfactory, especially those of students who took art as a subject.

5. Recording of data on the worksheets was done with accuracy. Each group discussed the findings before recording them.

6. The student teachers displayed considerable ability to work co-operatively.

Evaluation of the environmental approach as a teaching strategy

Having used an environmental approach as a teacher, the researcher has been compelled to evaluate it in practice as a teaching approach. The following strengths and weaknesses associated with the environmental approach to teaching have been identified.

Strengths

1. An environmental approach encourages active participation on the part of the learners. Active learning results in learning with understanding.

2. It allows for the use of a variety of learner-centred teaching strategies including fieldwork, games and simulations, and model building. The use of these teaching strategies generates an enthusiasm for learning.

3. It promotes conceptual understanding needed for the resolution of real-world problems.

4. It develops communication skills, skills needed for fieldwork activities, and critical thinking, by providing opportunities for dialogue, encounter and reflection.

5. It allows the teacher to swap roles: for example, in the initial stage while the open-ended test was administered the role of the researcher was that of teacher as transmitter. When the students were engaged in co-operative learning exercises the researcher acted as a facilitator, but in the construction and development of worksheets, her role was that of a co-learner.

6. It provides opportunities for critical thinking and evaluation.

7. It promotes societal investigation and resolution of local environmental problems - the main aim of education **for** the environment. The plan of action drawn by the learners was a step towards environmental improvement.

In general an environmental approach as a teaching strategy improves the quality of both teaching and learning.

Weaknesses

The following is a perceived disadvantage of an environmental approach.

It is time-consuming both in design and in use. The time factor was the only problem that was encountered by the researcher. The third field unit that was planned was not implemented owing to a lack of time. Time has been regarded as the major limitation of this study (3.7, Chapter 3).

5.5 SUMMARY

If an environmental approach is to be adopted to the teaching of geography, there must be a shift from the transmission style of teaching. A variety of participatory teaching strategies which develop skills necessary for sustainable living have to be employed. It has been demonstrated in this chapter that if the students are given opportunities for critical thinking and problem solving they are capable of taking responsibility for their own learning. It has also been emphasized that field research should be used as a means toward the resolution of environmental problems, and not as a way of inculcating 'appreciation' of the environment, as used to be the case in geography. The use of an environmental approach to the teaching of geography not only achieved the aims of environmental education but also those of geography.

The extent to which the teaching unit improved the student teachers' conceptual understanding in geography was also measured by means of a two-tier test, the results of which are presented in Chapter 6.

CHAPTER SIX

AN IDENTIFICATION OF STUDENT TEACHERS' CONCEPTUAL UNDERSTANDING THROUGH A TWO-TIER TEST

6.1 INTRODUCTION

The results of the open-ended test, discussed in Chapter 4, revealed the range and level of the student teachers' misconceptions with regard to the concepts that were identified as central to an understanding of water management as an environmental issue. Chapter 5 described an attempt to eradicate the misconceptions through the implementation of the teaching unit, which was based on an environmental approach to learning as identified in Chapter 2. The aim of the current chapter is to identify the extent of the student teachers' conceptual understanding after the implementation of the teaching unit. The Treagust and Haslam (1987) test was designed to indicate whether the teaching unit was successful in eradicating the misconceptions or not.

As indicated in Chapter 2, the learning theory embedded within education for the environment requires an exploration of the learners' prior knowledge before an attempt is made to provide new information on the issue to be studied. Since education **for** the environment promotes action needed for environmental protection and improvement, there is a great need for conceptual understanding and development. It is impossible to

solve environmental problems if sufficient knowledge about those problems has not been acquired. Much of this knowledge stems from an understanding of the basic concepts. Against the above background, the extent of the student teachers' conceptual understanding is identified in this chapter through the administration of a two-tier test. The structure of this instrument has been presented in Chapter 3.

6.2 THE TWO-TIER TEST

The Treagust and Haslam (1987) test has been used in this study as a preliminary identification of the students' knowledge of concepts that constitute the basic foundation to water mananagement as an environmental issue, before and after the teaching intervention. The test was successful in that it provided an immediate identification of the serious misconceptions which students had, with regard to the basic concepts relating to the topic (Chapter 4).

Secondly, the test was able to establish whether those misconceptions had been eradicated after the teaching intervention. But what the two-tier test did not do in this study was reveal the depth of conceptual understanding which evolved within the participatory and collaborative teaching unit. This is therefore seen as a potential weakness of the Treagust and Haslam (1987) test as it was applied.

The results which are set out in the current chapter refer to the student teachers' responses to the two-tier test (Appendix 2).

6.3 RESULTS OF THE TWO-TIER TEST

The answers relating to the role of the hydrological cycle are reflected in Table 6.1.

Table 6.1 : The Role of the Hydrological Cycle

	Test 1	Test 2	% Improvement
Correct answer	32.0	100.0	68
Helps plants grow	9.0	0.0	-
Purifies water	5.0	0.0	-
Supplies water during drought	4.0	0.0	-

A comparison between the student teachers' understanding of the role played by the water cycle in maintaining the balance between water usage and water replenishment, before and after the teaching unit was taught, indicates a great improvement in understanding. Whilst only 36 per cent of them managed to give correct answers relating to the role of the hydrological cycle in the first test, all the students (100 %) were able to identify the correct role of the hydrological cycle in the second test.

The student teachers' responses to the question on the necessity of catchment management are shown in the following table.

Table 6.2 : Catchment Management

	Test 1	Test 2	% Improvement
Where river originates (mountain)	36.0	100.0	64
Where tributaries join main stream	18.0	0.0	-
Where stream piracy occurs	16.0	0.0	-
Where river meets the sea	14.0	0.0	-

The results reflected in Table 6.2 above also indicate an improvement in the students' conceptual understanding. All of them recognized that in order to prevent water pollution, soil creep and siltation, minimal human settlement should be allowed in the catchment area because it is the source or origin of a river. The percentage improvement was 64. The conceptual understanding of catchment management was enhanced by the field trip to the catchment area. Through direct observation, students were able to identify the point at which the river originates and it was easy for them to understand the definition of the catchment area. The answers with regard to the nature of human impact on water resources are reflected in the table below.

Table 6.3 : The Human Impact on Water Resources

	Test 1	Test 2	% Improvement
Negative Impact			
Scarcity of water and an increase in water pollution	76.0	100.0	24
Positive Impact			
Many people will purify water	10.0	0.0	-
No Impact			
Water is stored in many large dams	8.0	0.0	-
Water is non-perishable	6.0	0.0	-

From Table 6.3 it is evident that all the student teachers realized the negative impact of the increasing human population on water resources after the implementation of the teaching unit. Although their performance was good (76%) in the first test, there was a percentage improvement of 24 after the second test. As mentioned in Chapter 4, better performance on this question in the first test was attributed to the awareness programmes shown on television and to the popularity of the section on population studies amongst geography teachers and students. The teaching unit, however, made it possible for those students who had doubts about the impact of overpopulation on water resources to recognize its negative impact.

The answers relating to whether water was perceived as a renewable or non-renewable resource are shown in Table 6.4.

Table 6.4 : Water as a renewable or non-renewable resource

	Test 1	Test 2	% Improvement
Non-renewable:			
Cannot be manufactured by factories	24.0	0.0	-
Renewable:			
Can be purified	16.0	4.0	-
Can be renewed through the hydrological cycle	16.0	96.0	80
Can be drilled from underground	14.0	0.0	-

Although about 54 per cent of the student teachers regarded water as a renewable resource in the first test, some of the reasons given to support their answers were not satisfactory (Table 6.4). Only 16 per cent of them related its renewal to the hydrological cycle. In the second test about 96 per cent of the student teachers maintained that water can be renewed through the hydrological cycle. There was a percentage improvement of 80. A small degree of conceptual misunderstanding was, however, identified in 4 per cent of the answers, which related renewal of water to purification.

The responses with regard to the sector of the economy which makes the greatest demand on the water supply in Umtata are reflected in the table below.

Table 6.5 : Sector Making the Greatest Demand on the Water Supply in Umtata

	Test 1	Test 2	% Improvement
Industry, for manufacturing purposes	44.0	80.0	36
Agriculture, for irrigation purposes	28.0	20.0	-
Municipality, for distribution of water in townships	18.0	0.0	-
CBD, because most people live in town	10.0	0.0	-

An examination of data relating to the sector of the economy which makes the greatest demand on the water supply in Umtata, also indicated an improvement in the student teachers' conceptual understanding. No student teacher perceived the municipality and the CBD to be economic sectors, as was the case in the first test (Table 6.5). The percentage of the student teachers who mentioned the industrial sector as the sector that makes the greatest demand on the water supply rose from 44 in the first test to 80 in the second test. The percentage improvement was 36.

About 20 per cent of the students, however, maintained that the agricultural sector makes the greatest demand on the water supply. This information was supplied to this group of student teachers by one of the municipal officials who was interviewed by them. They were not able to interview the town clerk. Other groups who interviewed the town clerk were informed that the industrial sector makes the greatest demand on the water supply.

The answers relating to the question on the sector of the economy which is most responsible for water pollution in Umtata are shown in Table 6.6.

Table 6.6 : Sector Most Responsible for Water Pollution in Umtata

	Test 1	Test 2	% Improvement
Industry	38.0	100.0	62
Agriculture	24.0	0.0	-
Residential Areas	20.0	0.0	-
CBD	18.0	0.0	-

An improvement in student teachers' conceptual understanding of water pollution is also reflected in Table 6.6. In the first test only about 38 per cent of them stated that the

industrial sector is most responsible for water pollution whereas in the second test this was confirmed by all of them. The percentage improvement in students' conceptual understanding of water pollution was 62.

The responses with regard to the most detrimental form of water pollution in Umtata are presented below.

Table 6.7 : Form of Water Pollution that is most Detrimental to Water Purity in Umtata

	Test 1	Test 2	% Improvement
Factory effluent	40.0	92.0	52.0
Littering	24.0	0.0	-
Soap froth from household washing	19.0	0.0	-
Sewage	18.0	8.0	-

In the first test factory effluent was regarded as most detrimental to water purity in Umtata by 40 per cent of the student teachers whereas in the second test it was mentioned by 92 per cent of them. The percentage improvement was 52. Sewage was perceived to be most detrimental to water purity by 8 per cent of the student teachers.

The student teachers' conceptual understanding of the relationship between water pollution and the chemical balance (pH) of water is reflected in Table 6.8.

Table 6.8 : Relationship between Water Pollution and the Chemical Balance (pH) of Water

	Test 1	Test 2	% Improvement
The pH of healthy rivers ranges between 4 and 6	6.0	0.0	-
Rain water is naturally slightly acidic	6.0	0.0	-
The pH of 7 indicates massive pollution	4.0	0.0	-
Sewage and industrial effluent affect the pH balance of water	2.0	100.0	98.0

It was difficult for the student teachers to understand the relationship between water pollution and the chemical balance (pH) of water in the first test. About 82 per cent of them did not attempt to answer the question and answers from 16 per cent of them reflected misconceptions about this relationship (Table 6.8). Only 2 per cent of them mentioned that sewage and industrial effluent affect the pH balance of water. In the second test all of them understood this relationship. The percentage improvement in conceptual understanding was 98.

This improvement is attributed to the fact that the student teachers were involved in conducting experiments (ie. water tests). To "do in order to understand" lies at the heart of

an environmental approach. The effectiveness of giving the learners an opportunity to do experiments has been reflected by this dramatic improvement in their conceptual understanding.

The answers to the question on the need for water conservation in South Africa are shown in the following table.

Table 6.9 : The Need for Water Conservation in South Africa

	Test 1	Test 2	% Improvement
Need for water conservation			
Limited rainfall and Frequent droughts	58.0	100.0	42.0
Uncertain			
RSA has large dams and lots of underground water	10.0	0.0	-
RSA is not a desert	6.0	0.0	-
No need for water conservation			
God will always provide us with rain	2.0	0.0	-

In Table 6.9 above it is indicated that the percentage of the student teachers who recognised the need for water conservation in South Africa rose from 58 in the first test to 100 in the second test. This increase resulted in a percentage improvement of 42.

The student teachers' conceptual understanding of environmental sustainability in relation to the use of water resources is reflected in Table 6.10.

Table 6.10 : Use of Water Resources for Environmental Sustainability

	Test 1	Test 2	% Improvement
Little or no understanding			
There must be enough water for purification	18.0	0.0	
Nothing should be done	16.0	0.0	
Flush toilet hundred times	8.0	0.0	
Good understanding	**58.0**	**100.0**	**42**
Complain and take action	28.0	100.0	
Collect rain water	18.0	100.0	
Use a shower only	8.0	100.0	
Place brick in cistern of the toilet	4.0	100.0	

The percentage improvement in conceptual understanding of environmental sustainability was also 42 (Table 6.10). After the implementation of the teaching unit all the student teachers were able to choose the correct possible ways in which water can be used in order to maintain environmental sustainability.

6.4 SUMMARY

From the above discussion it is evident that the teaching unit which was based on education for the environment was effective in enhancing the conceptual understanding of the student teachers at Transkei College of Education. Education for the environment has the potential to improve the quality of teaching and the students' conceptual understanding. In an ideal situation, it promotes action for the protection and improvement of the environment. It is against this background that its use in school subjects is recommended in Chapter 7.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

Environmental problems have created the need for assimilating the principles of environmental education in formal education. By locating the aims of environmental education within geography the aim of this study has been to identify and isolate criteria which can be used to implement an environmental approach to the teaching of geography. Another objective was to promote the use of this approach by the student teachers in their schools after leaving the college of education, so that the aims of both environmental and geographical education can be achieved. This study was done through action research, which was identified as one of the methods that could give the researcher an opportunity to develop, implement and monitor the activities, and still be in an advantageous position to evaluate the project.

7.2 RESULTS OF THE RESEARCH

A review of the available literature in both environmental and geographical education provides the practitioner with a considerable body of theory. The problem that the practitioner faces is how to relate the theory to practice.

Since the focus of this study was the implementation of theory, a means to bridge the gap between theory and practice was essential. The solution emerged through an analysis of currently accepted literature which included the ecological paradigm in geography, the Tbilisi Principles for environmental education and Fien's (1993) guiding principles for education, which inform both education for the environment and a socially critical learning theory.

This analysis made it possible for the researcher, as a geographer, to identify and isolate a set of criteria which could be used both as guiding principles and as principles of procedure for the implementation of an environmental approach to the teaching of geography.

The application of these guidelines was instrumental in achieving the goals of the study and led to the success of the teaching unit (Chapter 5).

Since an environmental approach adopted by this study cannot be separated from the ideas of social constructivist learning theory, the choice of teaching strategies and the procedures that were to be followed in the teaching unit emerged from this particular learning theory.

Furthermore, the learning theory embedded within education for the environment requires an exploration of the learner's prior knowledge before an attempt is made to provide new information

on the issue to be studied. For this reason it was necessary to identify the student teachers' initial conceptual understanding of water management as an environmental issue. The intervention by the researcher through the first phase of the Treagust and Haslam (1987) two-tier test (Chapter 3) revealed considerable misconceptions which highlighted the need for a multifaceted intervention.

The development of the teaching unit which followed therefore incorporated a variety of participatory teaching strategies. These included a collaborative learning exercise, a simulation game, role play, student conducted interviews, water quality tests, a map exercise and field research. These teaching strategies were chosen because of their ability to involve students in participatory learning leading to critical thinking and problem solving, which is central to an environmental approach adopted for the study (Chapter 2).

The use of participatory teaching strategies in the learning process proved worthwhile in that:

1. The aims of both geographical and environmental education were achieved through the development of the required concepts, skills and values.

2. The students as prospective teachers were exposed to real learning and teaching situations which encapsulated a critical thinking approach.

3. Each student teacher was exposed to the implementation of a variety of teaching strategies in practice. All of these strategies, being participatory and collaborative, are central to Fien's (1993) notion of an approach to education for the environment.

4. The value of the role of the teacher as a facilitator and a co-learner was highlighted, and the fact that effective teaching does not depend on a transmission mode was emphasized.

5. The student teachers were familiarized with the procedures involved when using an environmental approach as a teaching strategy.

Despite the problems of time and disruption to the teaching programme, the students were willing to work until they reached the stage where they understood the need for a plan of action.

Against the above background the following factors may be highlighted even within this small sample:

1. If geography is taught with an environmental approach it can contribute to a shift in the learners' perspectives so that they become aware of the need to solve environmental problems.

2. In achieving the aims of environmental education, particularly within the current environmental educational theory, we are achieving the aims of geography, and conversely, if we teach geography in the light of the ecological paradigm which underpins the 1985 syllabus, we are achieving the aims of environmental education.

3. While the aims of geography and environmental education are similar, a dichotomy arises from the methodology which teachers apply in geographical education. Thus if an environmental approach is to be adopted to the teaching of geography, there must be a shift from the transmission style of teaching. A variety of participatory teaching strategies which develop skills necessary for sustainable living have to be employed. This entails a shift from teaching **about** the environment, **in** the environment, to teaching **for** the environment.

4. Students, if given opportunities for critical thinking and problem solving, are capable of taking responsibility for their own learning. This highlights the value of the role of the teacher as a facilitator and a co-learner.

5. If geography is to continue to justify its place in the curriculum, at a time when both 'green and brown' issues are controversial in South Africa, it ought not to ignore the value of applying an approach which is central to education for the environment.

6. The application of an environmental approach will make geography more relevant to the life of the learners since their learning experiences will be related to their real world. In this way the learners will realize that geography is part of them and they are also part of geography. This has implications for the syllabus. Our syllabuses have to provide opportunities for real world experiences.

7.3 RECOMMENDATIONS

If we believe strongly that geography can solve environmental problems and if we see teachers as agents of change it is important that teachers should be aware of the value of using an environmental approach to the teaching of school subjects. This awareness can be fostered through:

(i) the formation of regional and district subject associations to function as a forum for subject teachers to share their expertise in an environmental approach with their colleagues, and constantly to seek the services of experts from organizations active in environmental matters.

(ii) in-service centres at national and local levels concentrating more on teaching strategies, including the use of an environmental approach, than on ways of improving examinations.

(iii) the employment of highly qualified subject advisers who will help teachers who experience problems with regard to the implementation of the current socially critical environmental approach.

(iv) the establishment of strong, official links between in-service centres and the education departments of universities responsible for teacher-training, to keep subject advisers and specialists informed about new developments in methods of teaching.

(v) Regular workshops both at the national and the local level should be conducted for primary and secondary school teachers as well as college lecturers on how to develop and implement environmentally-based teaching units, to ensure that progression takes place from primary through secondary to tertiary level.

(vi) Primary and secondary school teachers as well as college lecturers should work together to design teaching units that are relevant to their various local environments.

(vii) A compulsory, practical fieldwork project, prepared and conducted during the last two years of the college courses either individually or in groups, should be introduced. This implies a form of evaluation.

(viii) The setting of improved school environmental projects. The workshops conducted by Paxton (1994) revealed that project topics set by teachers were frequently too broad and non-specific for meaningful project work, e.g., "Conservation", "Wildlife" and "Endangered Species". Reflexive learning can be promoted through the setting of environmental projects which place emphasis on the local environment, teacher education and the development of resources.

The recommendation that projects should focus on environmental issues in the pupils' local environment is motivated by the following:

(a) The study and resolution of a local environmental concern is clearly more practical than taking on a national or international issue. It is also more likely to be familiar to the pupils, and thus to enable the mobilization of non-scientific experiential knowledge.

(b) By working on an issue such as the pollution of a local river, rather than water pollution in South Africa or in France, pupils are more likely to encounter the issue in its social context. The social features (history, economics, politics) of that issue are thus likely to become evident, and through engaging with them, dialogue might be stimulated.

(c) By focusing on local environmental issues pupils will be encouraged to work with members of their own community. This might foster group concern and remedial action in the community.

(d) The project design should encourage and support pupils in developing solutions to environmental problems. This approach recognizes the value of local knowledge and solutions and does not assume that an externally located 'expert' knows the required solution. Social change seems more probable if people 'on the ground' participate in developing and implementing solutions to environmental problems, rather than the change being imposed from outside. Furthermore, learning and understanding would be enhanced through action-taking associated with the attempted resolution of real problems.

For teacher education to support environmental project work the following should be included in both pre- and in-service programmes:

(a) guidance on the methodology of project work and the benefits of that methodology to motivate teachers to make full use of the potential it presents.

(b) instruction on the nature of the environment crisis to enable teachers to choose meaningful and appropriate project topics.

(c) exposure to organizations active in environmental matters to enable teachers to contact or refer their pupils to appropriate sources of support for project work.

(d) exposure to resource materials which could support project work.

For resource materials to support socially critical environmental education through project work it is recommended that they incorporate the following features:

(a) Resources should guide pupils and teachers in becoming active participants in the democratic functioning of local life. This might include mention of the democratic structures in their community and insight into democratic processes. This recommendation is motivated by the view that learning and knowledge can most usefully contribute to social change through the processes of participation and democracy.

(b) Resources should support pupils and teachers in their choice of project topics by including ideas for practicable projects in their local environment. In particular, examples of successful projects should be included, as these may provide an inspiring vision of what is possible.

(c) Resources should be developed to help information seekers respond appropriately to environmental days. The costly production of posters to promote environmental days should be reconsidered, in view of the seemingly limited educational potential of their existing design and content.

(ix) Networking should be supported. Environmental information resources should be effectively marketed and distributed, e.g. through national strategies, and there should be co-operation between libraries and environmental organizations to ensure that the required information is in place.

(x) Consideration should be given to the inclusion of compulsory questions in the senior secondary examination based on knowledge acquired through local project work.

7.4 CONCLUSIONS

A review of the relevant literature and the results of the research conducted suggest that the conventional approaches to both geography and environmental education are more likely to perpetuate the status quo than to contribute to the fundamental change required for the resolution of environmental issues. An alternative approach embedded in socially critical theory, which underpins the implementation of an environmental approach, is perceived as being more likely to contribute to appropriate social change. This theory encourages reflexive learning through the processes of dialogue, encounter and reflection within a social and historical context.

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APPENDIX 1.

NAME: _____ AGE: _____ SEX: _____

DIPLOMA: _____ YEAR LEVEL: _____

HOME TOWN: _____

STATE IF YOU ARE FROM A RURAL ____ OR URBAN ____ AREA.

ANSWER THE FOLLOWING QUESTIONS:

1. Does the hydrological cycle play any role in terms of water supply? Give a reason for your answer.

3. Is it necessary to protect or manage the catchment area of a river? Give a reason for your answer.

3. What will be the effect of the increasing human population on water resources?
Give a reason for your answer.

4. Is water a renewable or non-renewable resource?
Give a reason for your answer

5. Which sector of the economy do you think makes the greatest demand on the water supply in Umtata?
Give a reason for your answer.

6. Which sector of the economy do you think is most responsible for water pollution.
Give a reason for your answer.

7. What form of water pollution do you believe to be most detrimental to water purity in Umtata?
Give a reason for your answer.

8. Is there any relationship between water pollution and the chemical balance (pH) of water?
Give a reason for your answer.

9. Should we conserve water in South Africa?
Give a reason for your answer.

10. Is there any need to use water resources we have in order to maintain environmental sustainability? Support your answer with suggestions as to why and how should/should not water resources be used in a manner that could sustain the environment.

APPENDIX 2.

INSTRUCTIONS TO STUDENT TEACHERS:

The following pages contain **TEN** questions about water management. Each question has **TWO** parts: A multiple-choice response followed by a multiple-choice reason. You are asked to make **ONE** choice from both the Multiple-Choice Response section and **ONE** choice from the Multiple-Choice Reason section for each question. If you have another reason for your answer write it in the space provided.

Answer all questions on the seperate answer sheet.

1. Read each question carefully
2. Take time to consider your answer
3. Record your answer in the correct box on the answer sheet

   e.g. 8 [2] Reason [ ]
4. Read the set of possible reasons for your answer
5. Carefully select a reason which best matches your thinking when you work out the answer
6. Record your answer in the correct reason box on the answer sheet

   e.g. 8 [2] Reason [C]
7. If you change your mind about an answer, cross out the old answer and add the new choice

   e.g. 8 [2] Reason [~~C~~] A
8. If you wish to provide your own reason for the question, write this on the answer sheet in the space provided

   e.g. 8 [2] Reason [ ] _____
9. Do not forget to record your personal particulars on your answer sheet.

APPENDIX 2. (CONTINUED)

1. Does the hydrological cycle play any role in terms of water supply?

    1. Yes

    2. No

    3. Uncertain

because:

(a) It is only God who provides us with rain

(b) The hydrological cycle takes water from full rivers and gives it to dry rivers

(c) My parents have always sent me to fetch water from the river or tap. They have never sent me to fetch it from the hydrological cycle.

(d) It maintains the balance between water usage and water replenishment as it changes water into different forms, namely: vapour, solid and liquid through evaporation, condensation and precipitation.

2. Is it necessary to protect or manage the catchment area of a river?

    1. Yes

    2. No

    3. Uncertain

because:

(a) The river is already polluted and useless since the catchment area is the region at which the river meets the sea.

(b) The management of the catchment area would mean prevention of water from joining the main stream because the catchment area is the point at which the tributaries join the main stream.

(c) In order to prevent water pollution, soil creep and siltation, no human settlement should be allowed in the catchment area because it is the source or origin of the river.

(d) It would be difficult and expensive to manage the catchment area since it is where stream piracy occurs i.e. where a river is captured by another river.

3. The increasing human population will have _____ impact on water resources

1. A positive
2. A negative
3. No

because:

(a) Water resources are non-perishable

(b) There will be scarcity of water because the more the people, the greater the use of water.

(c) Many people will assist in the purification of water

(d) Dams are built on rivers in South Africa to store water from season to season and from year to year.

4. Water is a _____ resource

1. Renewable
2. Semi-renewable
3. Non-renewable

because:

(a) It cannot be manufactured by the factories

(b) It can be purified and used again

(c) It can be drilled from underground

(d) The hydrological cycle keeps the total amount of water and water vapour constant

5. _____ makes the greatest demand on the water supply in Umtata

1. Industry
2. Agriculture
3. Municipality
4. CBD

because:

(a) It is responsible for the distribution of water in the townships

(b) It needs water for generating electricity and for cooling and manufacturing purposes

(c) Crop cultivation needs great amounts of water for irrigation purposes

(d) Most people live in town

6. The sector that is most responsible for water pollution in Umtata is

1. Primary (Agriculture)
2. CBD
3. Secondary (Industry)
4. Residential areas

because:

(a) Oil and chemicals from manufactured products are drained into the river

(b) The population density is high and the rate of water pollution increases with population growth

(c) Sewage and dirty water from baths flows into the Umtata river

(d) Poisonous pesticides from the irrigated lands are washed into the river by rainfall.

7. The form of water pollution that is most detrimental to water purity in Umtata is

   1. Soap froth from household washing
   2. Sewage
   3. Factory effluent
   4. Littering

because:

(a) It is difficult to purify it

(b) It cannot be even used for irrigation purposes

(c) It is poisonous

(d) It is washed into the river when heavy rain falls

8. There is _____ between water pollution and the chemical balance (pH) of water

   1. A relationship
   2. No relationship
   3. Sometimes a relationship

because:

(a) Rain water is naturally slightly acidic

(b) The pH of healthy (unpolluted) rivers ranges between 4 and 6

(c) Sewage and industrial effluent discharges affect the pH balance of water

(d) The pH of 7 indicates massive pollution

9. Should we conserve water in South Africa?

1. Yes
2. No
3. Uncertain

because:

(a) South Africa is not a desert. There are other parts of the world that are drier than South Africa

(b) South Africa's average rainfall is less than 500 mm a year and is not regular, in other words, droughts often occur

(c) God will always provide us with rain

(d) South Africa has large dams and lots of underground water

10. Is there any need to use water resources we have in order to restore environmental sustainability?

1. Yes
2. No
3. Uncertain

Choose **FOUR** possible ways in which we can use water from the following:

10.1 (a) Use a bath rather than a shower because a shower wastes huge amounts of water

(b) Use a shower rather than a bath because baths can use five to ten times more water than a shower

(c) Use a shower and a bath so that there can be enough water for purification

(d) People should wash their bodies twice a week

10.2 (a) Complain to businesses, factories or farmers if you see them polluting rivers or wasting water, and conduct litter cleanups and water quality tests

(b) Do not complain because all local authorities and industries purify the water they use so that it can be re-used

(c) Complain and do nothing because it is the duty of those responsible for water pollution to take action

(d) Do not complain, instead conduct litter cleanups and build toilets in the rural areas

10.3 (a) Small amounts of water are wasted when flushing toilets, therefore, we can flush them as many times as we like

(b) Flushing toilets wastes huge amounts of water. If you have a flush toilet place a brick in the water tank (cistern) to reduce the amount of water used

(c) It is better not to use the toilet at all. Faeces should be left in the open veld to avoid the use of water

(d) Toilets that do not need the use of water should be introduced

10.4 (a) Encourage people to collect rain water from their roofs in containers because this can be used for gardening and other purposes

(b) In the garden use any kinds of plants because plants use the same amounts of water

(c) Do not worry about soil erosion in your garden because it does not lead to the loss of water

(d) Discourage people to collect rain water from their roofs in containers because the roofs are dirty.

APPENDIX 2. (CONTINUED)

ANSWER SHEET

NAME: _____ AGE: _____ SEX: _____

DIPLOMA: _____ YEAR LEVEL: _____

HOME TOWN: _____

STATE IF YOU ARE FROM A RURAL _____ OR URBAN _____ AREA

			My Reason
1. ☐	Reason	☐	_____
2. ☐	Reason	☐	_____
3. ☐	Reason	☐	_____
4. ☐	Reason	☐	_____
5. ☐	Reason	☐	_____
6. ☐	Reason	☐	_____

APPENDIX 2. (CONTINUED)

My Reason

7. ☐ Reason ☐

8. ☐ Reason ☐

9. ☐ Reason ☐

10.1 ☐ Reason ☐

10.2 ☐ Reason ☐

10.3 ☐ Reason ☐

10.4 ☐ Reason ☐

UMGENI VALLEY PROJECT

Joyce Nothemba Nduna
Head: Geography Department
Transkei College of Education
Private Bag X5111
Umtata
5100

21 June 1993

Dear Joyce

WATER QUALITY MANAGEMENT PROJECT

Thank you for your letter of 31 May.

Share-Net has several resources to support studies of catchment areas and water quality monitoring. I enclose herewith a complimentary sample of the latest kit that has been developed, the **Catchment Action Starter Kit**, which I hope will assist you and your student teachers in the study of your local river. These kits sell for R17,00, including VAT, postage and packaging, should you decide that you need more sets.

I also enclose the latest Share-Net catalogue of resource materials that are available, as well as the brochure about the Catchment Action project that has been initiated through GREEN South Africa.

If we can be of any further assistance to you, please do not hesitate to contact us here at the Share-Net office.

Yours sincerely

Trish

Trish Henchoz
for: Share-Net

P.S. I have also enclosed some other materials which we are able to provide free-of-charge, which I hope you can make use of.

APPENDIX 4.

UNIVERSITEIT VAN STELLENBOSCH
UNIVERSITY OF STELLENBOSCH

Fakulteit Opvoedkunde
Faculty of Education

TEL.: 772295/772300
TELEFAKS: 774336
TELEKS: 520383

VERW./REF.:

DEPARTEMENT DIDAKTIEK
DEPARTMENT OF DIDACTICS

STELLENBOSCH
7600
SUID-AFRIKA/SOUTH AFRICA

Tel: 02231-772292/3
Fax: 02231-832403

20 July 1993

Dear Joyce

Thank you for your interest in our programme and projects.

We are sending you information on:

1. EEPUS (Environmental Education Programme: University of Stellenbosch)
2. The Schools Water Project (SWAP)
3. The WE CARE PRIMARY project.

These are all projects which are being developed and coordinated by our unit.

Please do not hesitate to contact us if you would like further information.

Yours sincerely

Ina de Lange (SWAP project executant)
Heila Lotz (WE CARE project executant)

UMGENI WATER · AMANZI

Turn on the Tap to a Better Life

Our Ref.

Your Ref.

Enquiries

16 August 1993

Joyce Nothemba Nduna
Transkei College of Education
Private Bag X5111
UMTATA
5100

WATER RELATED INFORMATION

Please find enclosed information related to water conservation and water pollution. If it is not sufficient please do not hesitate to contact me and I will try to give you more information or supply you with the name and address of a contact person that will further help you.

Yours faithfully

BONGIE THABEDE
EXTERNAL EDUCATION OFFICER

UMGENI WATER
HEAD OFFICE • PO Box 9 • Pietermaritzburg 3200
310 Burger Street • Pietermaritzburg 3201 • Republic of South Africa
Telephone (0331) 454365 • Fax (0331) 422084

Chief Executive: GDJ Atkinson
Executive Directors: • AE Carlisle • CB Crooks • WN Richards • MH Trissler • B Walford • GD Ward

CHEMICAL BALANCE (pH)

Water (H_2O) contains hydrogen ions (H^+) and hydroxyl ions (OH^-). Pure deionised water contains equal numbers of H^+ and OH^- ions and is thus neutral (Ph 7), neither acid nor basic (alkaline). If the sample measured has more H^+ ions it has a pH less than 7 and is acid. If it has more OH^- ions than H^+ ions it is basic and has a pH greater than 7.

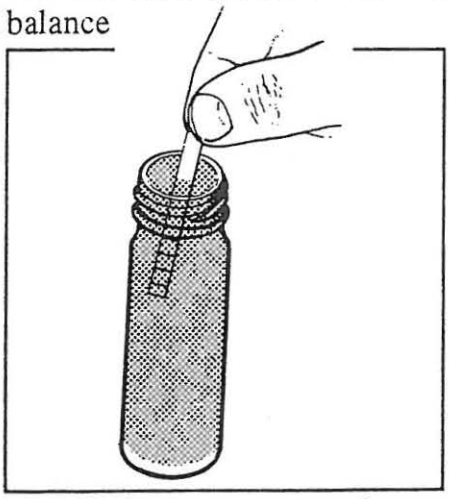
many H^+ — equal numbers — many OH^-

0 ◄——— pH7 ———► 14

acid — neutral — alkaline

Rainwater is naturally slightly acidic but the type of rocks and minerals in a catchment usually determines the pH. Limestone is alkaline and basalt very slightly acid. Atmospheric pollution (nitrogen oxides & sulphur dioxides) from vehicles and thermal power stations produces acid rain, a serious threat to aquatic systems particularly in the Eastern Transvaal. Sewage and industrial effluent discharges can also affect the pH balance

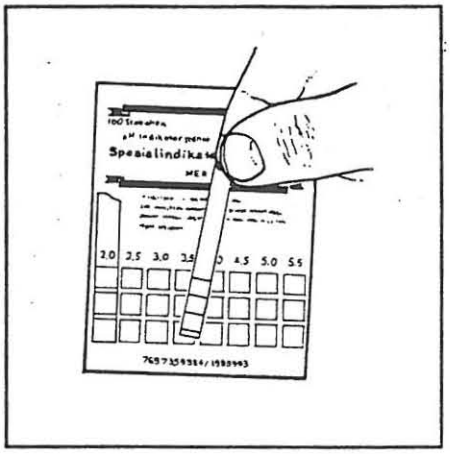
Paper packed pH test strips and colour code



Dip the pH stick into a water sample for about 15 seconds or until a colour change has taken place.

Did you know: The acid rain in the Eastern Transvaal appears to have caused a 0,1 pH change in all its rivers.

Compare the dip stick with the colour code and read-off a pH value.



An economising tip:

Dip sticks are convenient and reliable for testing the pH of water. They are, however, fairly costly so do not waste resources by doing this test more than once. To save costs cut the sticks in half (lenghtways) with a pair of sharp, clean, dry scissors.

Interpreting test scores

The pH of healthy rivers is usually neutral (7) or ranging between 6.5 and 8,5. Many 'black' rivers in the south western Cape can have a natural pH of 4-5 so be sure to get local advice when interpreting results.

On the whole, this testing technique provides accurate and reliable results.

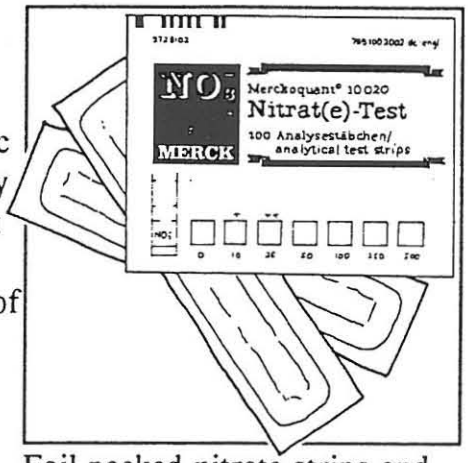
Record your results on the horizontal bar graph below:

0%	20%	40%	60%	80%	100%
pH < 5 or pH > 10 Massive pollution	pH 5-5,5 or pH 9,5-10 Highly polluted	pH 5,5-6 or pH 9-9,5 Pollution problems	pH 6-6,5 or pH 8,5 - 9 Imbalance	pH 6,5 - 8,5 Normal	

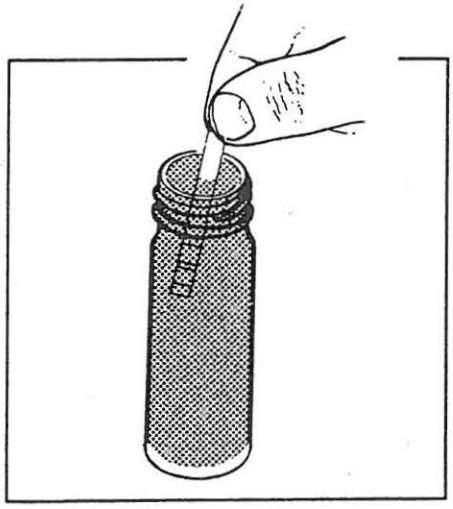
CHEMICAL ENRICHMENT (nitrates)

Nitrogen, as ammonia (NH_4) and nitrates (NO_3) are plant nutrients that may contribute to water quality problems. Nitrate enrichment through sewage contamination and fertiliser run-off is not as serious to water systems as that of phosphates. Aquatic ecosystems are not very sensitive to increases in nitrate levels as nitrogen is normally "chemically locked-up" and thus not available to plants. It can, however, be activated by excessive decomposition and by blue-green algae. Blue-green algae can convert nitrogen from the air (N_2) into ammonia and nitrates that can be used by aquatic plants.

This subtle interdependence illustrates the complexity of all relationships within aquatic ecosystems. The value of these water quality tests is not in the score you get for each test alone but in how each result relates to the others and contributes to an overall picture of water quality.

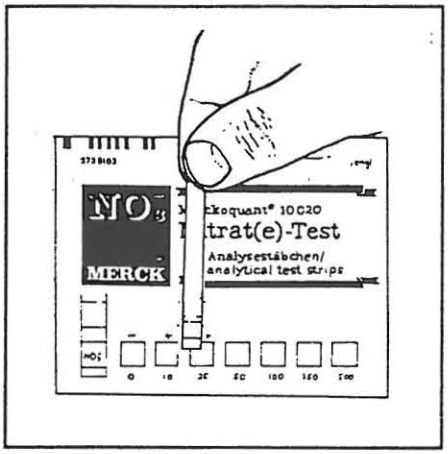


Foil packed nitrate strips and colour code



Dip the nitrate stick into the sample for one second. (Submerge, shake to remove bubbles, count 'one hundred and one' and then remove)

Did you know: High nitrate levels in water have been linked to 'Blue-Baby-Syndrome' a disease that can cause death in very young bottle-fed babies.



Wait for at least one minute and then compare the nitrate stick with the colour code. You must read the colour code before 5 minutes have lapsed or concentration by evaporation of the nitrate compounds may produce a blotchy colour change.

Interpreting test scores:

Southern African fresh water systems have low nitrate counts, especially in mountain catchments. Do not waste time and resources repeating this test unnecessarily.

Any reading with the Merck nitrate strip indicates a significant enrichment problem that needs attention. If there appears to be an enrichment problem but you do not get a reading with the test strip:

1. Boil down a sample to 50% by volume and test again; and
2. Use the Green low-cost kit or a commercial test kit to test for phosphate enrichment.

A concentration of 20-75 mg/l may indicate a severe problem. Natural levels are usually below 1-2mg/l and the SA standard is 1.5mg/l.

Record your results on the horizontal bar graph below:

0%	20%	40%	60%	80%	100%
100mg/l Severe pollution	< 50mg/l extremely polluted	20-30mg/l very polluted	10-20mg/l polluted	0-10mg/l enriched.	No colour change

APPENDIX 8.

FIELD UNIT 1: THE CATCHMENT AREA OF UMTATA RIVER (SITE A)

1. Define the hydrological cycle and explain which stage of the hydrological cycle provides the catchment area of the Umtata river with water.

2. Make a rough sketch of the catchment area of the Umtata river.

3. If you were the Minister of Water Affairs how would you conserve or protect the catchment area of this river?

4. (a) Who lives near the catchment area? (Describe the overall settlement pattern).

   (b) What do they do? (How is the land used?)

   (c) Distance of human activities from the banks

(d) Condition of the river bank vegetation

_____

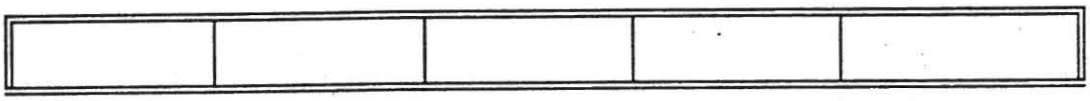
_____

(e) How do they dispose of waste? (Are there rubbish dumps?)

_____

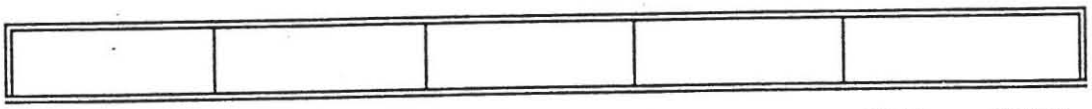
_____

5. Test the chemical balance (pH) of water and record your results on the horizontal bar graph below.



0%	20%	40%	60%	80%	100%
pH < 5 or pH > 10 Massive pollution	pH 5-5,5 or pH 9,5-10 Highly polluted	pH 5,5-6 or pH 9-9,5 Pollution problems	pH 6-6,5 or pH 8,5 - 9 Imbalance	pH 6,5 - 8,5 Normal	

6. Test the chemical enrichment (nitrates) of water and record your results on the horizontal bar graph below.



0%	20%	40%	60%	80%	100%
100mg/l Severe pollution	< 50mg/l extremely polluted	20-30mg/l very polluted	10-20mg/l polluted	0-10mg/l enriched.	No colour change

APPENDIX 8. (CONTINUED)

7. Should we conserve water in Umtata? _____

   If your answer is YES, give a reason for it

   _____
   _____

8. How should water resources be used in order to restore environmental stability

   (a) at our homes _____
   _____
   _____

   (b) in the economic sectors _____
   _____
   _____

oooo0oooo

APPENDIX 9.

FIELD UNIT 2: THE COURSE OF THE UMTATA RIVER AND ORANGE GROVE (SITE B)

Observe and record the following:

1. Litter (plastic, paper, cartons and cans)

   _____

   _____

2. Sewage, animal and human faeces (cloudy grey or green slime)

   _____

   _____

3. Waste water from household (soap froth)

   _____

   _____

4. Factory effluent (oil, froth or sludge)

   _____

   _____

5. Dead animals (dogs, cats, birds, frost etc)

   _____

   _____

6. Soil erosion (muddy water)

   _____

   _____

7. Any other observations

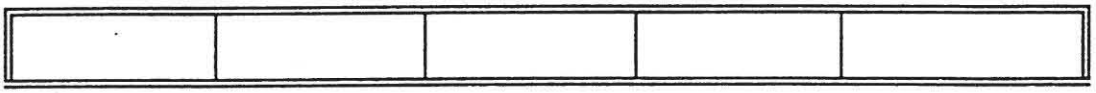
   _____

   _____

8. Test the chemical balance (pH) of water in site B and record your results on the horizontal bar graph below.

0%	20%	40%	60%	80%	100%
pH < 5 or pH > 10 Massive pollution	pH 5-5,5 or pH 9,5-10 Highly polluted	pH 5,5-6 or pH 9-9,5 Pollution problems	pH 6-6,5 or pH 8,5 - 9 Imbalance	pH 6,5 - 8,5 Normal	

9. Test the chemical enrichment (nitrates) of water in site B and record your results on the horizontal bar graph below.



0%	20%	40%	60%	80%	100%
100mg/l Severe pollution	< 50mg/l extremely polluted	20-30mg/l very polluted	10-20mg/l polluted	0-10mg/l enriched.	No colour change

10. In your opinion is the Umtata river used in a manner that can maintain environmental sustainability? _____

    Give a reason for your answer

    _____
    _____
    _____

11. Which sector of the economy:

    (a) makes the greatest demand on the water supply in Umtata? _____
    (b) Is most responsible for water pollution? _____
    _____

12. Which form of pollution is most detrimental to water purity in Umtata? _____

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APPENDIX 10.

OBSERVATION SCHEDULE FOR THE USE OF AN ENVIRONMENTAL APPROACH IN THE TEACHING UNIT.

Please indicate your observations concerning each of the items below by circling the appropriate rating in the column next to each item. The ratings used are:

1 Very weak
2 Weak
3 Satisfactory
4 Good
5 Excellent

1. Opportunity provided by the teaching unit for:					
(a) Active participation as opposed to transmission of knowledge	1	2	3	4	5
(b) Development of an informed concern for the environment	1	2	3	4	5
(c) Promotion of lifestyles for sustainable use of water resources	1	2	3	4	5
(d) Development of skills	1	2	3	4	5
(e) Exploration and resolution of an environmental issue	1	2	3	4	5
(f) Consideration of social as well as biophysical factors	1	2	3	4	5
(g) Social interaction as opposed to individualism	1	2	3	4	5
2. Shift in emphasis of the unit from:					
(a) Top-down messages to local co-operative and participatory action	1	2	3	4	5
(b) Nature experience approaches to action learning	1	2	3	4	5
(c) Conservation of natural resources to sustainability	1	2	3	4	5
3. Effectiveness of the unit in the:					
(a) Improvement of students' conceptual understanding	1	2	3	4	5
(b) Enhancement of the students' understanding of an environmental approach	1	2	3	4	5

APPENDIX 11.

STUDENT TEACHERS' EVALUATION OF THE USE OF AN ENVIRONMENTAL APPROACH IN THE TEACHING UNIT

PART ONE:

1. Please indicate your feelings about the use of an environmental approach in the teaching unit by circling the appropriate rating in the column next to each question.

2. The ratings to be used are:

1	Very weak
2	Weak
3	Satisfactory
4	Good
5	Excellent

1. The extent to which the teaching unit gave you an opportunity to:					
(a) Participate actively from the beginning to the end of the unit	1	2	3	4	5
(b) Develop an informed concern for the environment	1	2	3	4	5
(c) Develop lifestyles for sustainable use of water resources	1	2	3	4	5
(d) Develop skills	1	2	3	4	5
(e) Explore and try to solve an environmental issue	1	2	3	4	5
(f) Consider both social as well as biophysical factors	1	2	3	4	5
(g) To interact with other people in the solution of environmental problems	1	2	3	4	5
2. Shift in emphasis of the unit from:					
(a) Top-down messages to local co-operative and participatory action	1	2	3	4	5
(b) Nature experience approaches to action learning	1	2	3	4	5
(c) Conservation of natural resources to sustainability	1	2	3	4	5

3. The extent to which the teaching unit:

(a)	Improved your conceptual understanding	1	2	3	4	5
(b)	Enhanced your understanding of an environmental approach	1	2	3	4	5

PART TWO:

1. Which part of the teaching unit (preparation, actual fieldwork and follow up) did you find:

1.1 most interesting _____

1.2 most effective _____

1.3 most boring _____

1.4 most rewarding _____

1.5 easiest to understand _____

1.6 most practical _____

1.7 hardest to understand _____

1.8 most difficult? _____

2. Is there anything else that you wish to comment about concerning any aspect of the teaching unit?