AN INVESTIGATION INTO THE USE OF WEATHER TYPE MODELS IN THE TEACHING OF SOUTH AFRICAN CLIMATOLOGY AT SENIOR SECONDARY SCHOOL LEVEL

HALF-THESIS

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DECLARATION

I declare that this dissertation describes my original work and has not been submitted for a degree at any other university.

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ABSTRACT

The synoptic chart encodes climatological and meteorological information in a highly abstract manner. The pupil's level of cognitive development, the nature of the syllabus and the teaching strategies employed by the geography teacher influence the pupil's conceptualisation of information.

The synoptic chart is a valuable tool for consolidating the content of the S.A climatology syllabus. Recent research has established that climatology-meteorology, and especially synoptic chart reading and interpretation, is difficult for the concrete thinker. These pupils find difficulty in visualising the weather processes and systems.

Provided that they are simple and clear, models are useful teaching devices that integrate and generalise information in a manner that is easily retrievable. The intention of the author is to provide weather type models and other supporting strategies and aids as a means to improve the senior secondary pupil's assimilation of southern African climatological-meteorological information.

This model-based approach is tested in the classroom using an action research framework to judge its efficacy. Conclusions are drawn and recommendations are made.

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CHAPTER 1

INTRODUCTION

Meteorology-climatology relies on an understanding of highly abstract concepts and relationships within weather systems and patterns. The abstraction is added to by the very vehicle used to communicate weather systems and patterns, viz. the synoptic chart. The synoptic chart is a communication system employing a 'language' consisting of profound and condensed symbolic forms. The understanding of the synoptic chart is underpinned by a definite body of knowledge and involves a network of specific graphic skills and concepts, the acquisition of which is determined by perceptual quality. The enhancement of the processes of perception and conceptualisation is related to learning theory.

The writer has demarcated four problem areas concerning the teaching of meteorology-climatology.

1. The meteorology-climatology component embraces many abstract concepts that are difficult for adolescents progressing from the stage of concrete operations to that of formal operations (Graves, 1975; Vrey, 1979).
2. Meteorology-climatology is taught in a fragmented fashion with little attempt made to integrate the various elements into a synthesis by way of a planned and progressive development of concepts (Van Jaarsveld, 1988).

3. Hurry and Van Heerden's guide to South African weather patterns (1982) makes use of satellite photographs and synoptic weather maps. Valuable as this guide is, it fails to solve the problems that pupils have in visualising maps three-dimensionally (Burton, 1986). School geography text books offer few three-dimensional visual illustrations.
4. Classroom strategies tend to be teacher-centred (Ballantyne, 1986) and stifle discovery learning.

There are ways of dealing with these problems. Van Jaarsveld (1988) regards the sequential and graded teaching of climatological concepts as the solution to the problem of poor conceptualisation. Burton (1986; 1988/89) recommends the development of three-dimensional graphicacy skills through planned stages. Both authors believe that to help pupils grasp the abstractions of the synoptic chart, teaching must respect the findings of the developmental theorists.

In the preamble to the 1985 revised geography syllabus as adopted by the Cape Education Department, guidelines for the effective teaching of the syllabus are given. It is stated that the pupil's concept of space is influenced by the way in which the environment is perceived in relation to the actual environment. Mention is made of the development of skills such as graphicacy and the interpretation of pictures, photographs and maps, among others. The document also advises that teachers are to create effective learning experiences for their pupils. Among the approaches described to achieve this goal is the use of models: theoretical models that enable generalisations to be made, and physical models which effectively represent the real world. The writer's conviction is that a more vigorous use of models can heighten pupil perception and conceptualisation and improve graphicacy in the context of the teaching of the synoptic chart.

A number of classroom strategies has been recommended to alleviate the problems associated with the teaching of mapwork and synoptic charts. The use of models may offer a solution to the problems of poor conceptualisation. As a learning device, the model is valuable in that it structures thoughts in such a way that they may be easily retrieved, and it assists the pupil's movement from concrete operations to formal operations (Nightingale, 1981). Models are carefully constructed approximations or generalisations that reflect only the fundamental and relevant aspects of reality (Walford, 1969). The study of weather systems, with their characteristic three-dimensional development is ideally suited to a model-based approach.

Based on the definitions given of weather type and climate model by Monkhouse, Steyn and Boshoff (1983) and Preston-Whyte and Tyson (1988), a weather type model can be defined as a generalisation of repeating weather patterns designed to predict future patterns. Such models can assume the form of theoretical models and physical or hardware models.

Weather type models combine synoptic maps with schematic diagrams and simplified images of the relevant weather patterns. Such weather type models minimise the inessentials (noise) that cloud the pupil's perception of the weather reality and emphasise general climatological relations. A weather type model provides a simplified synthesis of particular southern African weather conditions in such a way that three-dimensional visualisation is aided.

THE GOALS OF THE RESEARCH

The purpose of this research was two-fold:

1. The development of curriculum units based on weather-type models and supporting strategies to facilitate the teaching of southern African climatology in an integrative manner.
2. The evaluation of the use of such a teaching approach.

THESIS OUTLINE

Chapter 2 constitutes a literature review in which the perceptual-conceptual problems associated with map reading and synoptic chart interpretation are examined in the light of (i) certain developmental theorists, and (ii) the syllabus. The use of models, and in particular, weather type models, is explored to provide a solution to the problem of poor conceptualisation in the study of S.A. climatology.

In Chapter 3 the methodology employed in the research is discussed. The implementation of an action research approach involving a number of procedures in two research settings is described and evaluated. In this regard, permission was granted by the Chief Superintendent, East London on behalf of the Cape Education Department to conduct classroom-based research at a school in the East London area.

Chapter 4 investigates the weather type model in its theoretical and hardware forms. The characteristics, function, and place of the models in the S.A. syllabus are set out. The development of the models used in the research, their value, and the use of supporting strategies and aids are then discussed.

The results of the action research is the subject of Chapter 5.

Chapter 6 presents the conclusions and recommendations based on the research.

CHAPTER 2

THEORETICAL CONSIDERATIONS REGARDING THE DEVELOPMENT OF GRAPHIC SKILLS IN METEOROLOGY-CLIMATOLOGY IN THE SENIOR SECONDARY SCHOOL

Boardman (1983), Burton (1986) and Van Jaarsveld (1988) have researched the difficulties that pupils experience in working with contour maps and synoptic chart interpretation and have suggested strategies to teach these components more effectively. Cognisance of their research findings must be taken if a teaching strategy employing a model-based approach is devised to make the teaching of meteorology-climatology in the context of synoptic charts more effective. The situation poses some challenging questions. If the pupils' understanding of the content and concepts of mapwork and synoptic chart interpretation is lacking, how can the inter-meshed processes of perceptualisation and conceptualisation be enhanced? Can this difficult area of the syllabus, which appears to be teacher-centred, not benefit more from better pupil participation? Are teachers not attempting to adapt the pupil to the curriculum, thus ignoring the fact that children develop through phases and are unable at times to grasp certain concepts? In an attempt to answer these questions, this chapter will consider the following:

1. Graphicacy and the perceptual-conceptual problems inherent in mapwork and synoptic chart interpretation.
2. Problems in the secondary school syllabus itself.

3. The use of weather type models as a didactic bridge between concrete and abstract thought.

4. The use of supporting strategies and aids in the teaching of this aspect of the geography syllabus.

2.1 GRAPHICACY AND THE PERCEPTUAL-CONCEPTUAL PROBLEMS IN MAPWORK AND SYNOPTIC CHART INTERPRETATION

Graphicacy involves the communication of information in a visual manner (Ballantyne, 1983). Burton (1986) concurs with Balchin's (1972, 1973) belief that graphicacy ought to be regarded as an underpinning of education along with literacy, articulacy and numeracy. Ballantyne (1983) supports the argument that geography as a school subject ought to develop graphic skills which promote spatial concepts, and emphasises the need to develop these skills throughout the school curriculum. He maintains that if spatial skills and concepts are not adequately catered for in the primary school phase, then the pupil's progression towards the hypothetico-deductive thinking essential to the grasping of abstract areas, such as mapwork and synoptic chart interpretation, in the secondary school years will be retarded.

According to Gerber and Wilson (1984), a map is a complex graphic document which communicates an abstracted, generalised and scaled representation of the earth's surface. To interpret a map's highly selective and conventionalised representations of the real world requires that certain difficult perceptual and conceptual skills have to be mastered (Bailey, 1974). Burton (1986) believes that a visualisation of two-dimensional and three-dimensional space is the key to understanding maps.

2.1.1 RECENT RESEARCH RELEVANT TO THIS THESIS

Burton's thesis (1986) investigates the problem of poor performance in relief mapwork in terms of three-dimensional mapwork skills. Three key questions are addressed and they are: what skills are involved, when should they be introduced and how should they be taught? He approaches the problems of three-dimensional graphicacy from four perspectives or research fields, viz:

(i) the map itself with its symbolic representations;

(ii) the neurophysiological processes involved in working with maps;

(iii) the perception of space involving the visualisation process and cognition; and,

(iv) the level of the user's conceptual development in terms of the views of Piaget and Bruner concerning pupil readiness.

Burton conducted a number of experiments to identify the skills involved in contour mapwork with different age groups, to determine when contour mapwork should be taught by testing the perceptual and conceptual processes involved in mapwork, and to explore the realm of three-dimensional thinking.

Based on the findings of these experiments he answers the three key questions posed at the outset by compiling a structured list of the skills to be taught, a scheme of work to meet the needs of the pupil at his/her particular stage of intellectual development, and a teacher's guide to the teaching of the relevant mapwork skills.

It is clear from this research that South African pupils experience difficulties in visualising a two-dimensional map in three dimensions. Burton ascribes the above mentioned problem to the following:
(i) The syllabus does not accommodate the fact that pupils pass through various phases of intellectual development;
(ii) The syllabus does not provide a progressive sequence of mapwork skills that accommodate those intellectual phases.

Van Jaarsveld (1988) has made a valuable contribution towards a better understanding of the problems that pupils experience with regard to synoptic climatology in the light of the pupils' cognitive development. He identifies the lack of graded and sequential teaching of basic concepts and the three-dimensional visualisation of the two-dimensional representation of reality as general problems. The concepts and problems associated with synoptic chart interpretation are akin to, and often more complex than, those encountered in topographical mapwork as described by Burton (1986, 1988/89). Using Boardman's (1983) list of graphicacy skills, Van

TABLE 2.1 A comparison of graphicacy skills applicable to topographic maps and synoptic charts (adapted from Van Jaarsveld, 1988:64-65)

AGE AND ORDER OF SKILL	GRAPHICACY SKILLS ASSOCIATED WITH TOPOGRAPHIC MAPS	EXAMPLES OF HOW THE GRAPHICACY SKILL CAN BE EXTRAPOLATED TO SYNOPTIC CHARTS
11 - 13 Basic	1. Give 6 figure grid reference.	Give co-ordinates of weather station model, low pressure centre etc.
	2. Measure curved distances.	Determine the extent of fronts using the ratio scale 1:20 000 000.
	3. Describe a route.	Describe the movement of a cyclone by consulting a sequence of charts.
	4. Identify and draw conventional symbols.	Identify warm/cold fronts draw weather station models given particular data.
	5. Read heights on contours and estimate heights between contours.	Read and infer pressures by inspecting isobars, and determine pressure difference between isobars.
	6. Draw a cross-section of map contours.	Draw a cross-section through a cyclone.
	7. Calculate vertical exaggeration.	Appreciate the vertical exaggeration of profiles.
	8. Calculate gradient of a slope.	Calculate the pressure fall over a given distance.
	9. Calculate area.	Calculate the areal extent of a tropical cyclone.
	10. Identify simple topographic features.	Identify basic pressure patterns eg. ridge, col. trough, tongue.
	11. Annotate a landscape map from a photograph	Annotate a satellite image from a synoptic chart.
	12. Describe a landscape using combined evidence	Describe prevailing weather at a given place

TABLE 2.1 cont.

	of map and photograph.	using satellite image.
13 -16 Intermediate	13. Generalise about the height of the area.	Generalise about the intensity of prevailing pressure systems.
	14. Identify overall relief divisions.	Identify zones of high and low pressure, cyclones and anti-cyclones.
	15. Describe the shapes of slopes.	Recognise and describe steep and gentle pressure gradients.
	16. Describe the nature and pattern of rivers in a drainage basin.	Describe air flow patterns around pressure systems.
	17. Correlate features on the photo with those on the map.	Correlate features on the satellite image with those on the synoptic chart
	18. Use the combined evidence on map and photo to make inferences about human activity.	Use the combined evidence on synoptic chart and satellite image to make inferences about anticipated weather.
	19. Construct a landscape model from a map and show selected features on it.	Convert two-dimensional pressure patterns to their three-dimensional equivalents.
16 -19 Advanced	20. Identify relief patterns and suggest origins.	Identify pressure patterns and describe/suggest origins.
	21. Identify drainage patterns and suggest reasons for them.	Identify air flow patterns and suggest reasons for them, eg. geostrophic flow gradient flow, sea breezes contrary to prevailing pressure flow.
	22. Designate stream order.	Infer stage of maturity of atmospheric weather phenomena.
	23. Read geology maps and relate rock strata to relief and drainage.	Read rainfall maps and relate weather phenomena to climatic regions.

Jaarsveld compiled a comparison of graphicacy skills applicable to topographic maps and synoptic charts to be mastered within certain age groups (Table 2.1 above).

It must be borne in mind, however, that synoptic chart skills in the intermediate and advanced phases may not correlate on a one-to-one basis with those required for topographic map interpretation as the former involves a greater degree of mental abstraction encompassing covert and definitional skills. For example, with reference to item 12, while a thirteen year old pupil may be capable of describing a landscape using a map and a photograph, it is doubtful whether he would be able to describe the prevailing weather at a given place using a synoptic chart and satellite photograph until he reaches the intermediate phase.

Van Jaarsveld identifies a number of difficulties presented by the synoptic chart amongst which he includes the following:

(i) Both geopotential metre isolines and isobars are used.

(ii) An unobservable and intangible reality is represented.

(iii) A dynamic reality is represented on a small scale of 1:20 000 000 at a particular moment.

(iv) The map's clarity is diminished and demands of the pupil greater visual perception and a spatial conceptualisation characterised by sophisticated mental processes.

After examining the import of Piagetian and Ausubelian psychology to adolescent understanding, this study discusses the implications of their theories for the teaching of synoptic charts. An examination of the senior secondary climatology syllabus, school textbook content, matriculation examination papers, and an analysis of current classroom practice leads Van Jaarsveld to conclude that the climatology component of the senior secondary syllabus embraces many abstract concepts that are beyond the immediate experience of the teacher and pupil and that this may account for the fact that the climatology section in the standard 10 paper is not answered competently and that rote learning rather than conceptual understanding is fostered. He identifies the portrayal of weather phenomena in three-dimensions, the isohypse concept and geostrophic flow as the three most important problems encountered by pupils. He completes his thesis by presenting a number of classroom activities to aid the teaching of meteorology-climatology.

From a study of the aforementioned authors' works, a key factor which emerges is the vital role played by perception and conceptualisation in pupil understanding.

2.1.2 PERCEPTION AND CONCEPTUALISATION

The construction of conceptual schemes is rooted in the pupil's perception of the real world (Weimann, 1986). Graves (1975), in discussing the perceptual and conceptual learning problems that pupils have, stresses that conceptualisation and perception interact. Concept formation is aided by what is perceived, but existing concepts also guide to some extent what is perceived.

Perception

Perception may be defined as the way in which sensory information is interpreted by the brain (Van den Aardweg and Van den Aardweg, 1989; Papalia and Olds, 1985). Van Jaarsveld (1988) mentions that observation and identification of details in a given situation is matched with existing mental structures in the perception process. However, a person's perception of various stimuli consists of more than the sum of individual sensations, because perception has a Gestalt quality (ie situations are perceived as some sort of organised whole and not as isolated, meaningless entities) which arises out of the inter-relationship between elements (Mouly, 1973). Lindgren (1976) recognises that both experience and perception are aspects of behaviour larger than specific responses and that a learner organises the stimuli of the learning situation into a pattern or whole that is meaningful to him by drawing on previous attitudes and skills. Perception is therefore defined by the Gestaltist as:

> " a unitary process, in which sensation hinges on meaning and meaning on sensation, and sensing and finding meaning occur simultaneously" (Bigge and Hunt in: Vrey, 1979:19).

An important aspect of perception is that it is unique to the perceiver and is coloured by the perceiver's previous experiences so that no two people perceive in the same way (Mouly, 1973; Vrey, 1979; Papalia and Olds, 1985).

Duminy (1975) maintains that "the most complicated learning relies on sense perception of the concrete world" (p.39), and that perception is the only effective and natural way through which the child is introduced to the world.

Perception encompasses all five senses, but in this thesis the writer concerns himself with visual perception only. Difficulties arise in both the direct observation of the real world (eg perception of the passing of a coastal low) and in the study of vicarious or secondary evidences such as maps and photographs (Graves, 1975; Van Jaarsveld, 1988; Burton, 1988/89). Pupils in the senior secondary phase, by virtue of their wider experiences, should have wider perceptual fields and should be more selective in their observations as they develop powers of hypothetico-deductive thinking (Graves, 1975). However, teaching that divorces itself from what Marsden (1976) terms the 'ground' in the formative years, can result in perceptual problems and in the development of impoverished mental sets or cognitive maps.

Van Jaarsveld (1988) lists a number of perceptual problems that present themselves in the context of synoptic charts:

(i) A general problem is that of perceiving a two-dimensional plan view three-dimensionally.

(ii) The synoptic chart symbols represent intangible reality, eg. height contours on a topographical map simply display tangible variations in the height of the land above sea level, whereas the isolines over the land on a synoptic map represent an intangible pressure surface, and the picture is further complicated by the use of isobars over the sea.

(iii) The very small scale (1:20 000 000) of the synoptic chart gives rise to a cluttering of abundant information and results in diminished clarity.

(iv) A full understanding of the dynamic weather systems on the synoptic chart requires an examination of a sequence of maps and aerial photographs.

Conceptualisation

Conceptualisation is a form of categorising and is a means of reducing the complexity of the environment (Yelon and Weinstein, 1977). Conceptualisation involves the formation of concepts or the association of ideas which make up a person's thoughts, ideas, feelings, impressions, understanding and views (Van den Aardweg and Van den Aardweg, 1989). Graves (1975) defines a concept as a classificatory device enabling the mind to structure reality in a simplified manner by concentrating on the essential attributes of particular experiences. Concepts vary according to their difficulty. At their simplest they are overt and describe concrete, observable features and processes without an awareness of causal relationships, eg. clouds. Those that are most difficult are definitional concepts which express relationships abstractly, eg. isobaric surfaces. Taking an intermediate position between concrete and abstract concepts are those that Van Jaarsveld (1988) defines as covert concepts which are unobservable but measurable and must be experienced before they can be conceptualised, eg. humidity and temperature.

Because concepts can be hierarchically arranged, it follows that geography teaching must reflect a grading of learning material in line with the developmental phases posited by educational psychologists such as Piaget and Bruner. Graves (1975) also stresses the importance of language acquisition in concept formation, and Weimann's research (1986) bears out the fact that the terminology of geography must be linked to the pupils' real world perception upon which rests the construction of conceptual schemes.

According to Ausubel (<u>in:</u> Vrey, 1979; Van den Aardweg and Van den Aardweg, 1989), meaningful learning is linked to conceptualisation as it depends on the clarity of the particular concepts present in the learner's cognitive structure. Unlike rote learning, which is merely association, memorisation and reproduction of learning material not necessarily understood or assimilated, meaningful learning makes sense and is substantively related to the learner's present knowledge and in turn involves a change in perception and understanding.

The relationship between perceptual development and conceptualisation is further clarified by looking at the theories of certain developmental psychologists. The following section deals with the contributions made by Piaget, Bruner and Ausubel.

2.1.3 CONCEPTUALISATION IN THE LIGHT OF THE DEVELOPMENTAL THEORIES OF LEARNING

Piaget

Piaget maintained that learning involves the internalisation (ie. assimilation and accommodation) of experiences of reality into the cognitive structure through successive phases, viz: the sensori-motor phase (0-2 years), the pre-operational phase (2-7 years), the concrete operational phase (7-11 1/2 years), and the formal operational phase (11 1/2 years and older) (Vrey 1979). Although later research disputes that the chronological or mental ages associated with Piaget's stages are fixed, the stages are nevertheless invariant in sequence (Marsden, 1976). The latter two phases are of relevance to this research.

According to developmental theorists most children entering the secondary school are in the stage of concrete operations - they are capable of logical thought which is tied to concrete experiences and dependent on perceptual facts around them. Their lack of experience and mental development precludes them from using generalisation based on hypothesis testing and logical deductive thought (Graves, 1975; Marsden, 1976). Later in the secondary school phase, there is a tendency to move away from concrete thinking towards hypothetical thinking involving abstraction. This phase, called the formal operations period, is characterised by the ability to solve problems by the internal processes of thinking and by experiment - there is no longer a reliance on visible aids or concrete props as in the former phase. The phase is also characterised by hypothetico-deductive thought.

It must always be borne in mind, however, that these phases are not chronologically fixed and that not all senior secondary pupils reach the age of hypothetico-deductive thinking. Most people encountering a new problem revert to concrete operations to make the problem clearer as they have not acquired the conceptual framework to understand in generalised terms (Graves, 1975; Vrey, 1979).

Applied to the teaching of climatology, Piaget's developmental theory has valuable import. Firstly, the Piagetian phases aid the understanding of learning problems encountered at school. For example, the overemphasis on detail rather than a synthesis of details in the interpretation of synoptic charts is explained by the centration principle; the fact that many pupils in the senior secondary school cannot grasp many covert and definitional concepts can be attributed to their lack of first hand experience and their inability to work with abstract ideas and generalisations (ie. hypothetico-deductively) while being essentially concrete thinkers. Secondly, Piaget's theory is a valuable guide to sequential, graded learning. Thirdly it throws light on the problem of choosing the correct teaching strategies suited to the various developmental phases. Lastly, his principle of assimilation, whereby new experiences and information are perceived because of their similarity to previous experiences and information already existing in the child's schema, reveals the danger of cramming or crash-coursing in teaching. Elkind (1974) in interpreting some of Piaget's essays on how children learn, claims that assimilation is better accomplished through 'horizontal elaboration' of skills rather than 'vertical acceleration' of learning which does not appear to have long-lived benefits. It follows, therefore, that to cram the teaching of synoptic weather patterns in standard 10 would be dangerous in that it diminishes interest and motivation and serves short term memory only. It would be better to teach weather patterns by gradual elaboration and building of concepts over an extended period of a few years. This elaboration process will be discussed more fully later.

Bruner

Bruner's interest lies more in the processes of cognitive growth than in the structure of intelligence at various stages (Ing, 1981). His cognitive theory stresses the influence of external, experiential factors on intellectual development, and the understanding of a subject's concepts, principles and procedures by the learner. He advocated discovery learning in which pupils discover for themselves concepts, meanings and relationships through adapting the curriculum to the pupil rather than the pupil to the curriculum. He envisaged a spiral curriculum in which subject matter is suited to the child's readiness and is used in increasing complexity as the child develops over time. He believed that the active involvement of the pupil in problem solving enhances understanding (Van den Aardweg and Van den Aardweg, 1989, Vrey, 1979).

Bruner's ideas reiterate to a large extent what Piaget says: that learning can take place only according to the pupils' level of development, and, that learning material must be graded and sequentially taught for better consolidation of concepts. His ideas on meaningful learning, best accomplished through discovery in problem solving situations, justifies the use of games.

It is the application of Bruner's less rigidly defined three stages in cognitive development that is of great use to consolidation of learning, viz: the stages of enactive, iconic and symbolic representation. There is a tendency, in the writer's experience, to proceed from the symbolic (eg. the synoptic chart) and work backwards to the enactive (the real world). In keeping with the sound principle of working from the known to the unknown, the procedure ought to be from the enactive situation (the real, tangible and experiential world), to the iconic (the use of pictures and other vicarious material representing reality) to the symbolic situation (the use of abstract concepts).

Ausubel

Ausubel's contribution to the understanding of the learning process lies in his opinion that successful learning depends upon a stable and clearly organised cognitive structure. Such a cognitive structure is acquired through the assimilation of meaningful new material built on relevant anchoring ideas, ie. the new material must be related to the old before it can be psychologically meaningful. The relevance of Ausubel's theory to teaching geography is obvious: if the pupils' understanding of climatological/ meteorological concepts is lacking, then it is because that material has not been adequately related to previous material anchored in the cognitive structure.

Synthesis

The problem areas that the writer has demarcated involves the senior secondary pupil or adolescent whom the syllabus designers take for granted is able to think in a hyopthetico-deductive manner. Many pupils do not reach Piaget's phase of formal operations in the latter half of their secondary schooling, so that teaching of abstract climatological concepts must depend on concrete reality either directly or second hand. Greater attention should be paid to accommodating the enactive and iconic modes according to Brunerian psychology. The introduction of new concepts should always flow from sound, meaningfully constituted anchorage ideas. Graves (1975) believes that for a successful emancipation towards generalised propositions in the latter secondary school years, it is vital to concentrate on contact with reality directly or at second-hand in the formative junior secondary phase. He concurs with Ausubel in realising the need to return to concrete examples when introducing new topics.

2.2 SYLLABUS PROBLEMS REGARDING THE TEACHING OF S.A METEOROLOGY-CLIMATOLOGY

In addition to the perceptual and conceptual difficulties involved in the teaching and learning of climatology-meteorology, there are further problems relating to the syllabus content and sequence that must be mentioned.

(i) Fragmentation. A perusal of the 1985 revised geography syllabus as adopted by the Cape Education Department reveals that climatological concepts are taught in piecemeal fashion over the five year secondary school phase. Frontal depressions, berg winds and advection fog, for example, are introduced in standard 6 and much later elaborated upon in standard 10; the thunderstorm (Taljaard's model) is introduced in standard 8, line thunderstorms in Standard 10 ; and upper westerly waves in Std 9 with little or no relation to the systems in the lower atmosphere. It appears that there is a lack of flow or continuity in syllabus material. The result is that climatological aspects are lost in the overall maze of the syllabus. A cohesion is required to bring the strands together in a purposeful and planned fashion.

(ii) Temporality. Flowing from the problem of fragmentation is the tendency to teach weather patterns as isolated frozen glimpses as though they exist briefly. Such an approach does little to promote an appreciation of how weather systems progress or change over time. Sequential studies are necessary if the isolated glimpses are to be put into a time perspective. In this way cause-effect thinking is also developed.

(iii) Degree of abstraction. Some concepts, such as warm and cold fronts in frontal depressions taught in Standard 6, involve a high degree of abstraction and are perhaps too difficult for the junior pupil. Research done by Boardman (1983) and Burton (1986) reveals that junior pupils have visualisation problems with contour maps arising from the highly abstract nature of the contour map. Difficulty in rotating mental images from a plan view to a side view is considered another common problem. Many isobaric concepts such as troughs, ridges, and saddles are similar to those used in contour maps, except that unlike contour patterns isobaric configurations are imperceptible in the atmosphere, so that one can expect to encounter similar if not more serious visualisation problems in pupils' understanding of synoptic charts. It appears, therefore, that some concepts, such as frontal depressions, would be better placed later on in the syllabus.

2.3 BRIDGING THE GAP BETWEEN CONCRETE AND ABSTRACT THINKING

It would appear from the aforegoing that what is required is a 'didactic bridge' between the concrete and abstract modes of thinking. Such a bridge ought to have the following characteristics:

(i) it must proceed from that which is familiar or concrete to the child (enactive mode of representation) and must always relate new material to previous material anchored in the cognitive structure;

(ii) it must progress from the simple to the complex and in such a way that the pupil's level of cognitive development is always respected;

(iii) it should incorporate the use of illustrative media (iconic mode of representation) to give expression to the unseen and abstract concepts (symbolic mode of representation) which cannot be encountered first hand;

(iv) it should emancipate the concrete thinker, who is in the habit of focusing on particulars, towards the ability to generalise or think on a macroscale.

Much of the complex realm of knowledge, which lies beyond the experience and reach of the pupil, can be presented vicariously or artificially through the use of illustrative material. The important advantage of such material is its ability to aid the arrangement and organisation of learning in a concrete setting (Duminy, 1975), and in the provision of a "visual background to take the place of the more chancy, if more colourful, visual imagery of the children themselves" (Gopsill, 1973:174). It is the use of models as illustrative devices designed to bridge the gap between concrete and abstract thinking that is considered in the next section.

2.3.1 THE USE OF WEATHER TYPE MODELS IN THE TEACHING OF METEOROLOGY-CLIMATOLOGY IN THE SENIOR SECONDARY SCHOOL

Models in general

Walford (1969:20) defines a model as:

> "selective approximations which by elimination of incidental detail, allow some fundamental, relevant or interesting aspects of the real world to appear in some generalised form."

Monkhouse, Steyn and Boshoff (1983:220-221) distinguish between the following types of model:

(i) Hardware models which provide a scaled three-dimensional reproductions of physical phenomena such as landscapes.

(ii) Theoretical models which bring together various aspects of reality "forming a bridge between observation and theory, and providing a working hypothesis against which reality can be tested" (p.221). According to Walford (1969) such models help in the identification of the nature of physical representations of reality as depicted in hardware models. There is a range of theoretical models including amongst others:

* iconic models representing some aspect of the physical world with only a change in scale (eg. an aerial photograph), and,
* analogue or symbolic models in which actual properties are represented by other or analogous properties (eg. isolines representing aspects such as relief or atmospheric pressure on a map; mathematical equations).

Models are useful in the learning process. Models allow two or more concepts to be related and out of the linking of different sets of phenomena emerge ideas of structure and system. They structure thoughts in such a way that they can be easily retrieved and they are especially valuable in assisting pupils who depend on concrete operations to move to generalised thinking which is characteristic of formal operational thought. They also assist in the transfer and application of knowledge from one situation to a similar one.

There are a number of disadvantages associated with the use of models, however. Bailey (1974: 68) warns that models can oversimplify reality to the extent that they can "suggest a system of relationships which is so tidy and schematic that it becomes untrue". The pupil may see the model as the real world and not as a fallible idea which is open to alteration. Models can also be learned by rote without understanding the concepts involved. Pupils sometimes fail to understand that the model is a generalisation of reality, and they consequently test reality against the model rather than the other way round. These problems can be overcome by the careful teacher who uses more than the model as a teaching aid.

Climate models

Preston-Whyte and Tyson (1988: 319) state that the modelling of the constituent parts of an atmospheric system and their interaction is the primary objective in almost all aspects of meteorology and climatology. Climate models (also referred to as atmospheric models) are theoretical models and are tools used to understand climatological processes with a view to prediction of the effects of changes in those processes. Climate models provide a dynamic approach through which the temporal and areal variations in climatic elements is explained in terms of the large-scale atmospheric circulations and the weather types responsible for climate (in: Barnard and Nel, 1981:1).

Among climatic models encountered in the secondary school syllabus are the frontal and tropical depression models, thunderstorm models, the geostrophic wind equation, the structure of the atmosphere, cloud classification models, the tri-cellular general circulation model, weather station models, slope wind models, and the heat budget model. From this cursory list something of the great diversity of models used in climatology is illustrated. The subject of this study however, is the weather type model; thus, at this point the concepts 'weather type' and ' weather type model' require clarification.

Weather types

Monkhouse (1983:357) defines a weather type as a "generalised type of synoptic pressure pattern with its associated set of characteristic weather conditions". Weather types involve the deduction of a series of future repeating patterns based on the analysis and comparisons of patterns of weather situations from previous years. It may be asked on what basis the weather types are classified. Tyson (1986) classifies South African weather types into three categories of circulation patterns in which generalised surface circulation types with their attendant upper-level counterparts are identified (Figure 2.1 below).

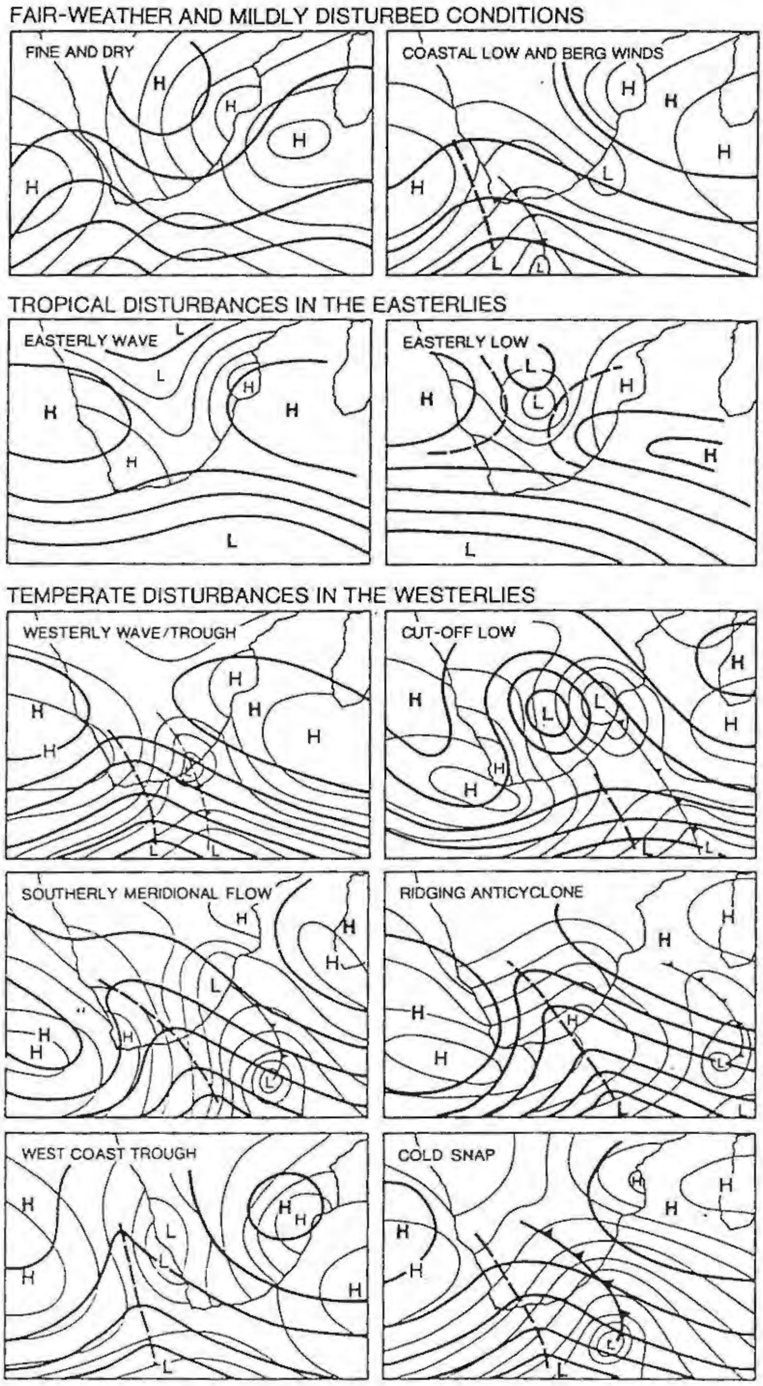


FIGURE 2.1 Three-category classification of S.A. weather types according to Tyson (1986:124)

There are parallels between Tyson's classification and that used in this thesis, except that the weather types referred to have been adapted to those weather patterns that fall within the scope of the senior secondary syllabus. For example, the syllabus does not stipulate that easterly waves and easterly lows be taught; however, many of the concepts in these two types are important for understanding the life cycle of line thunderstorms in summer which is included in the syllabus.

<u>Weather type models</u>

As weather types are generalisations of repeating weather patterns designed to predict future patterns, they can by definition be regarded as theoretical models. The term 'weather type model' as used in this thesis, however, embraces more than only a theoretical model. The frontal depression, for example, can be represented by a schematic or cross-sectional diagram, or by various hardware models. Each type of representation offers a generalisation of the pertinent aspects of the frontal depression and can be used as a tool to understand the climatological processes involved in this particular weather phenomenon, ie. they are all weather type models. Weather type models therefore include both theoretical models and hardware models.

The weather type models used in this research were devised to overcome the problems associated with fragmentation, temporality and abstraction discussed earlier. The hardware models provide both three-dimensional perspectives and plan views to facilitate the visualisation of the weather systems and the rotation of mental images through ninety degrees from plan to overhead views. The physical manipulation of hardware models by pupils and teacher is something that theoretical models in school textbooks can never accomplish.

The theoretical models were devised in an attempt to improve upon the way in which weather types are presented in school textbooks. The models cohere the various S.A. climatological aspects taught throughout the secondary school phase in a planned and purposeful fashion, and combine cross-sectional schematic diagrams with their synoptic representations and key concepts. The third dimension is introduced to help the pupil to visualise concretely the highly abstract patterns shown on the synoptic map. The learning material, therefore, involves a progression from iconic representation vital to the concrete thinker to the symbolic representation characteristic of the abstract mode of thought.

The diversity of abstract concepts involved in the teaching of climatology may require an equal diversity of strategies and teaching aids. The section below presents strategies and aids that can be used to support the teaching of weather types.

2.4 SUPPLEMENTARY STRATEGIES AND AIDS

The following strategies have been identified:

(i) Games and simulations are practical models designed to teach certain aspects such as interrelationships, facts and trends in an enjoyable manner.

(ii) Paper models and hard models are useful in portraying invisible or intangible aspects such as cyclonic circulation, and for combining depth and plan perspectives.

(iii) Overhead projector transparencies placed over a base map can illustrate very effectively the dynamic nature of systems such as the movement of cold fronts over the subcontinent and the backing of winds.

(iv) A measure of realism can be injected into the climatology course by using daily newspaper synoptic charts combined with television forecasts to study changing weather patterns. A study of East London's weather (Appendix 1) devised by Mr. A. Cheel of Selborne College serves as good example of the type of assignment that can be completed at Standard 8 level in which pupils are made sensitive to local weather patterns and data accumulation. Newspaper weather reports were also used to check the reliability of television forecasts over the space of a week. A similar assignment was done using 1970 and 1985 flood statistics and information.

The hard models and overhead transparency models are elaborated upon in Chapter 4, as they were specifically developed for the second stage of the research which is the subject of that chapter.

Games as practical models

Walford (1969) considers games a practical part of model theory as they simplify reality and include the essential factors of a particular situation. They combine educational techniques with relevant subject matter in an informal and enjoyable manner. There appears to be little agreement on a precise definition of the word game. Some use game and simulation in the same way, others prefer to distinguish between the two (Nightingale, 1981; Walford, 1969). For the purposes of this study, the writer distinguishes between the following:

- a game involving a contest between contestants according to rules, and having as its objectives the learning of factual information; and,
- a simulation game in which a real life complex situation is simplified into a model to teach weather processes, eg weather forecasting using depressions.

The former type is well suited to teaching memorisation of facts and may assume the format of a snakes and ladders/ludo type game where progress depends on the throw of a dice and the correct answering of questions. The weatherships game (Appendix 2.) was applied by Butts (1987) to frontal depressions over the Britsh Isles and can be adapted to the S.A. situation. It is useful as an aid to understanding the relationships that exist between different climatological variables. Its aim is to consolidate knowledge of weather patterns and is best used with single-type patterns such as frontal depressions, berg winds, tropical cyclones and others. Composite-types showing a number of systems and patterns are too complex and time consuming to use in a game situation. Examples of single-type southern African synoptic charts are given in Appendix 2. Butts has found that such a game can be completed in less than two 35-minute periods by 13-15 year olds, pupils with higher ability complete the game in a single lesson.

A weather forecasting game using depressions would help develop forecasting skills and the understanding of the influences of depressions on weather. The Depression Game is a simulation game devised for British conditions. Van Jaarsveld (1988: 196) lists the aims as:

(i) to make the variability of the British weather more real;

(ii) to provide an understanding of the influences on British weather; and,

(iii) to build on climatology as a real means of understanding changes in weather.

The game has been adapted to the S.A. situation by the author and appears in Appendix 3.

The advantages of using games are many. Simulation games go beyond descriptions of patterns by highlighting the processes involved. Gunn (1970) regards the simulation game as a bridge linking the real world with abstract ideas of reality and it therefore aids the pupils clear thinking and understanding of the facts and processes involved. The fact that students show a keen interest in simulation games has been established (Hails, 1979; Gunn, 1970). They inject enjoyment and enhance interest and motivation and encourage peer-learning, co-operation and competitive activity. (Nightingale, 1981; Hurry, 1980). Besides creating a flexible, responsive learning environment, a good simulation game can undergo modification to adapt to local situations without losing its efficiency (Fien, Herschel and Hodgkinson, 1984). Games do have educational value provided that they are seen to be one among many techniques in teaching.

Bailey (1974) warns that if games are to be manageable, they must be relatively simple and that their simplification of an extremely complex reality can be facile and dangerous. It must be remembered that simulations are not a replica of reality but a shadow reality (Walford, 1986).

The design of games requires careful planning. They have been criticised for taking too long to complete, for focusing on material that has little education value and for requiring

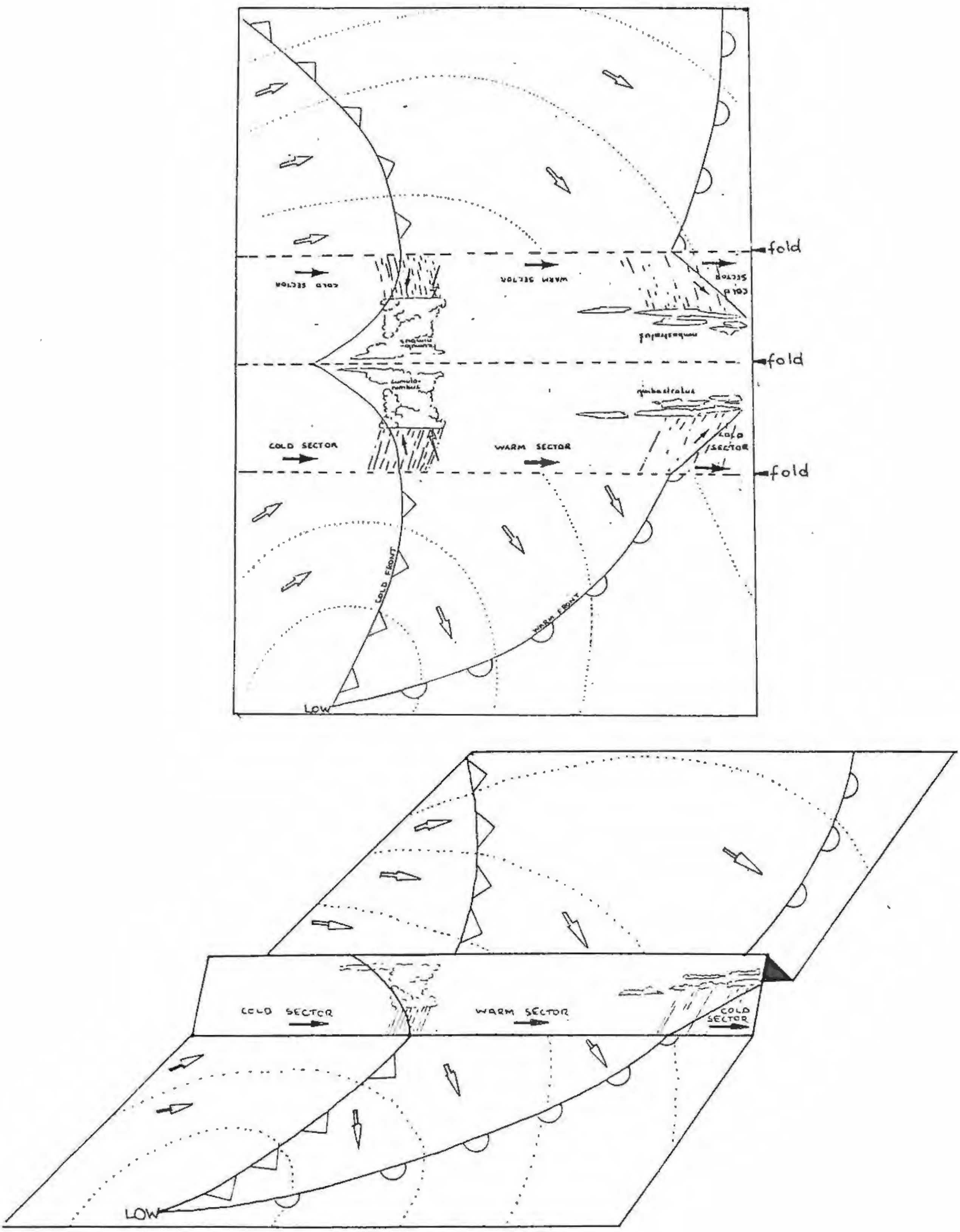


FIGURE 2.2 Paper model illustrating a frontal depression in the southern hemisphere.

too much preparation in setting up. Some are also complicated and not easily explained in a classroom situation.

Hardware models

The paper model illustrated in Figure 2.2 above was adapted from Grenyer (1985:47) and has the advantage of producing both a plan view (as is used in a synoptic chart) and a vertical section through a frontal depression. It is also possible to show more than one vertical section. Two sets of folds could be used to show the occlusion stage near the centre of the depression and active frontal conditions in the middle of the system. A similar model can be used to illustrate tropical depressions, anticyclones, depressions and the Taljaard model of line thunderstorms.

2.5 SUMMARY

The perceptual-conceptual problems related to the teaching of synoptic chart interpretation were examined. It was deduced that many of the problems are akin to and more complex than those experienced in topographic map interpretation. One reason for those problems relates to the underdevelopment of graphic skills which in turn is attributable to the unrealistic expectations that are harboured with respect to the concrete thinker who has difficulty in thinking abstractly. Other reasons can be found in the syllabus and the manner in which synoptic chart interpretation is taught. A solution to these problems appears to lie in the use of weather type models which include hardware and theoretical models and act as a didactic bridge between concrete and abstract thinking. Supporting strategies and aids that could be used to enrich pupil understanding involve the use of games and simulations, paper and hard models, overhead projector transparency overlays and case studies.

CHAPTER 3

RESEARCH METHODOLOGY

The research was conducted in two stages. The identification of problems associated with the reading and interpretation of synoptic charts with respect to weather patterns, and the development of weather type models as a strategy to enhance the pupil's understanding of those patterns, comprised the first stage. The second stage of the research was conducted in two settings. In the first setting, an experimental design was used to determine the effectiveness of one particular weather type model as a learning device (without teacher involvement in the usual teaching-learning situation) with a standard 10 class. The experimental procedure adopted is explained later in the chapter. In the second research setting, a descriptive design based on a case study was used to evaluate the use of weather type models as a teaching tool. An attempt was made to describe qualitatively the natural process of development observed in the classroom, rather than to establish cause and effect through quantitative means as was the case in the former design.

This chapter examines the methodology associated with the identification of the problems, the development of the weather type models, and, the testing of those models in an action research situation.

3.1 ACTION RESEARCH

An action research approach was used in this study. This type of research is used to find solutions to ethnographic problems and provides an understandable and workable approach to the improvement of educational practice through critical self-reflection. Action research may be defined as a type of research undertaken by practitioners into their own practices, ie. the practitioner is involved in the action process (Kemmis in: Dane, 1990; Verma and Beard, 1981).

According to Cohen and Manion (1989) action research can be described as having a situational character in the sense that it is a small-scale intervention in a specific situation and examines the effects of that intervention in order that precise knowledge (rather than scientific generalisation) for a particular situation and purpose is obtained. In addition to the strong situational character of action research, a further three features deserve mention: action research is usually collaborative as researcher(s) and practitioner(s) work together; it is participatory as team members are involved in the research; and, it is self-evaluative in that modifications within the situation are continuously evaluated in order that practice may be improved (Cohen and Manion 1985).

Seen in the context of this study:

(i) Situationally the researcher occupied two roles.

Initially, as a teacher involved in the teaching of climatology from standard six to ten, the researcher devised the weather type models in an attempt to alleviate the problems identified. In the second stage, the researcher as an outsider and participant observer, examined the effects of a model-based teaching strategy on the teaching and learning of various aspects of S.A. climatology with two small groups of standard 9 and standard 10 pupils.
(ii) In the first stage, there was no collaboration with team members in the research. In the second stage, the regular teacher of the two classes collaborated in the research as a non-participant observer by recording his observations of the lessons on an observation schedule. He then indicated his perceptions of the course as a whole in summary.
(iii) The pupils participated in the first stage by receiving instruction based on the weather type models. In the second stage of the research, they completed questionnaires on their perceptions of the lessons. Their understanding of the lessons was also gauged by means of achievement tests designed to test recall and application of weather type information.

Action research that is classroom-based, involves many participants each with his individual values and perceptions. Any teaching situation is created and coloured by all those acting within it, so that each participant can contribute something valuable to the overall research exercise. An inquiry by one of the participants alone (eg. the teacher) would yield one-sided findings. It is necessary, therefore, that triangular techniques be used to explain more fully the complexity of the classroom situation by viewing it from more than one standpoint (Cohen and Manion, 1989). Investigator triangulation was achieved by means of another geography teacher acting as a non-participant observer.

Triangulation may be defined as qualitative cross-validation (Wiersma, 1986) involving two or more methods of data collection in researching an aspect of human behaviour (Cohen and Manion, 1989). It implies explaining the richness and complexities of a situation from various perspectives so that there is a minimising of bias or single observational style that would distort the researcher's view of reality.

According to Wals, Beringer and Stapp (date unknown) action research ought to be a continuous spiral process comprising three phases: plan development that aims to solve a problem, plan implementation, and evaluation of the effectiveness of the exercise. A new plan emerges out of the evaluation and the whole process or cycle is repeated, thereby incorporating new ideas and meeting the needs of the changing situation. Based on the above notion a particular research model was required to suit this study.

The model sought for this research had to exhibit the following characteristics:

(i) It had to be flexible enough to accommodate the two stages through which the research evolved.

(ii) Both formative and summative evaluation had to be accommodated.

(iii) Because the study was a pilot study, the model had to be cyclic.

A number of action research models are available, however, Elliott's model was felt to be most pertinent to this study as it fulfilled the structure within which the study developed.

3.2 THE USE OF ELLIOTT'S ACTION RESEARCH MODEL

Hopkins (1985) discusses Elliott's action research model (Figure 3.1) which is an elaboration of Kemmis' schema of the action research spiral.

Applied to this research, the initial idea that was identified involved the more effective teaching of S.A. climatology. A 'reconnaissance' (using Elliott's terminology) involving fact finding and analysis revealed that pupils have conceptualisation problems relating to S.A weather patterns and the synoptic chart, and, that a teaching strategy ought to be developed to consolidate the concepts taught in the secondary school in a way that leads to better visualisation of those patterns and concepts. This

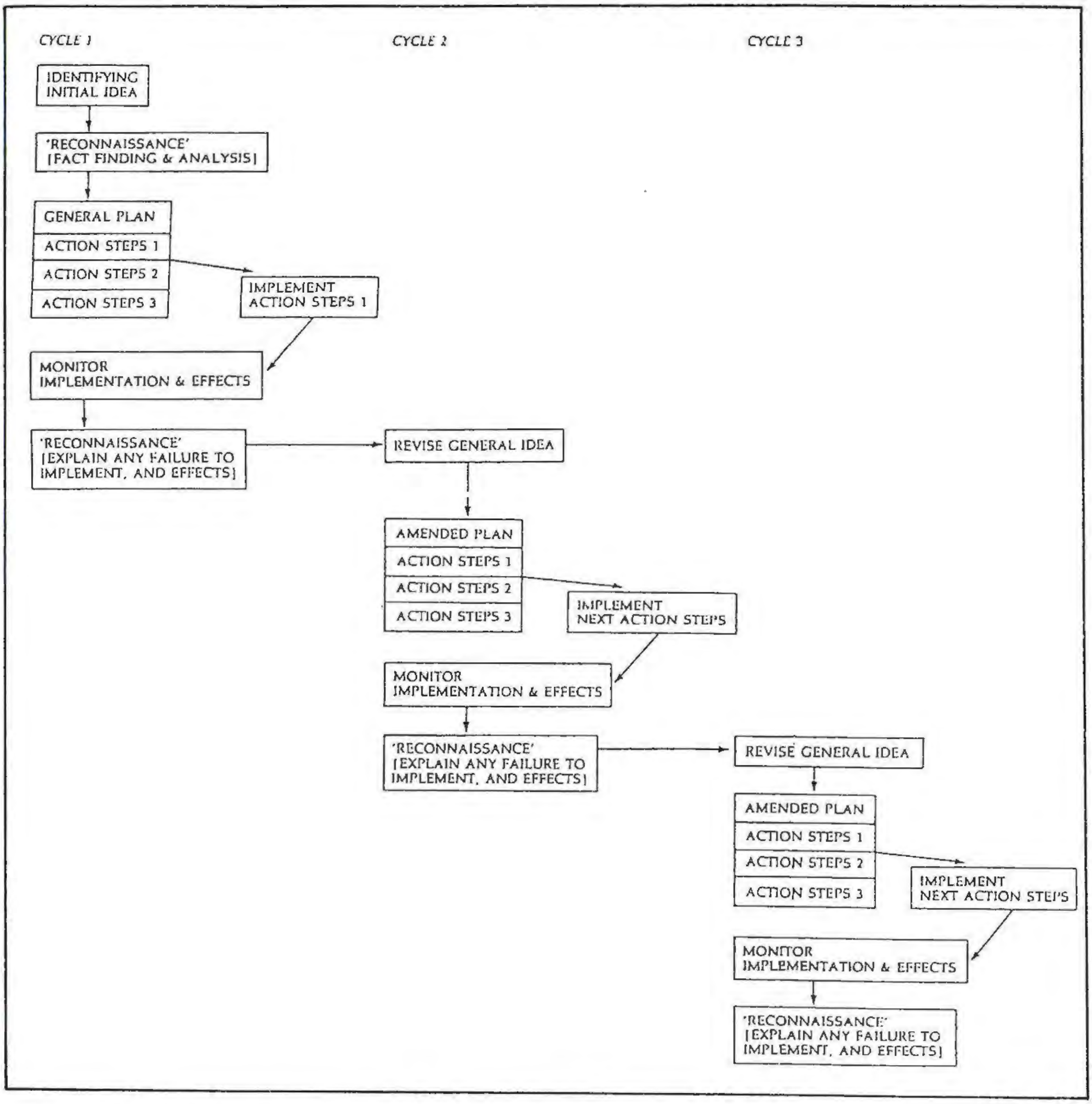


FIGURE 3.1 Elliott's action research model (After Hopkins, 1985:36)

'reconnaissance' is the subject of Chapters 2 and 4.

The general action research plan incorporated three steps.

* Action step 1: Theoretical weather type models based on synoptic chart patterns were devised to aid the pupils' understanding of climatological concepts and their visualisation of weather patterns in the southern African context.

* Action step 2: Hardware models were devised to enhance the teaching of the weather types.

(Steps 1 and 2 also constituted the first stage of the research exercise).

* Action step 3: Evaluation instruments were developed to test the effectiveness of the use of weather type models as teaching-learning devices in two settings. (This step constitutes the second stage of the research exercise).

The implementation and effects of the use of weather type models was then monitored using a number of evaluation instruments. The implementation and monitoring of the action steps are dealt with in detail later in this chapter and in chapter 5.

The final 'reconnaissance' is a reflection on the implementation and effects of the action steps employed and is the subject of chapters 5 and 6. Such a reflection ought to lead to the revision of the general idea and the whole cycle is then repeated. However, because of its nature and contents, this study may be seen as a pilot study employing only the first cycle of the action spiral.

Elliott's model does have one drawback in the context of this research. This model does not consider the fact that research of an ethnographic nature evolves and cannot always be premeditated. For example, the weather type models were first developed to solve a problem in the classroom, there was no intention or plan at that stage to test the models in a research setting.

3.3 APPLICATION OF THE MODEL TO STAGE ONE

The first stage comprised firstly, the identification of the problems associated with the reading and interpretation of synoptic charts. Thereafter, the development of the weather type models as a possible solution to the problem is set out.

In the course of teaching secondary school pupils from standards six to ten over a period of thirteen years, the researcher identified the following problems related to the pupil's understanding of synoptic chart interpretation:

(i) While the key concepts had been taught, many pupils (especially those on the standard grade) exhibited difficulties with the consolidation of climatological facts and concepts into a meaningful whole as is required in the interpretation of synoptic charts.

(ii) Pupils had difficulty in relating the synoptic chart theory taught in the classroom to the weather reality outside.

(iii) While pupils were able to read or identify synoptic features on a map, they displayed uncertainty concerning higher order skills such as generalising, analysing and predicting. The researcher identified rote memorisation rather than understanding as the reason for this problem.

(iv) Pupils often indicated that synoptic chart questions in the examination were unpopular, and, that those questions that carried the fewest marks for synoptic chart interpretation were chosen in the examination.

(v) The synoptic chart questions in the examination paper were poorly answered.

(vi) Textbooks used in the school offer few three-dimensional diagrams to illustrate weather processes and systems.

From the above-mentioned difficulties a problem could be pinpointed : What teaching/learning device could be developed to enhance the tandem processes of perception and conceptualisation so that pupil understanding of synoptic charts could be aided?

Theoretical weather type models were designed in 1989 by the researcher in an attempt to solve the problems listed above, and more specifically, for the following purposes:

(i) To improve the pupil's visualisation of intangible weather processes and patterns in the southern African context.

(ii) To establish and consolidate the concepts that were taught in the secondary school.

(iii) To establish the major components that comprise southern African weather.

(iv) To teach these components in a progressive manner from simple types to complex types.

The theoretical weather type models were then printed and bound into small study guides to be used in the classroom. It became clear that more could be done to improve pupil visualisation of weather types and to instil enjoyment in learning about them by developing supporting material such as hardware models and simulation games to illustrate frontal depressions, coastal lows, and the like. Journal articles and various text books were consulted. In this regard the British journal Teaching Geography was especially helpful.

3.4 APPLICATION OF THE MODEL TO STAGE TWO

The point has already been made that the nature of this study demands that a method suited to a particular rather than the general or universal situation be employed. McElroy (1984) recommends that a case study approach be used in classroom-based research where particularisation and improvement are important features of the research. The case study is essentially research in depth rather than in breadth. Such evaluation has the advantage of revealing new knowledge from the familiar and in a way that is not overly intrusive or foreign to the research participants. The case study is also well suited to research involving small response groups. Furthermore, case studies are a 'step to action' as they begin in a world of action and contribute to it and although they are difficult to organise, they are 'strong in reality' and down to earth. (Adelman in: Cohen and Manion 1989:150).

This case study can be criticised for the fact that the non-participant observer was not an outsider, but the actual teacher of the class. Bias may have occurred in his evaluations and the pupils reaction to the lessons may have been affected by his presence. McElroy (1984) advises that the participants ought not to be intimately involved so as to minimise a blinkered view.

A disadvantage of the case study method is that it must be time consuming to be of value. This case study suffers that limitation owing to the time restrictions imposed on it by the school circumstances.

While this study was based on the tenets of action research, the procedures followed were in fact a case study application of action research. A comprehensive study was conducted in a particular area of the syllabus with a minimum of interference in the day to day activities of a small class of pupils in one school. A model-based approach devised to improve the teaching of S.A climatology was evaluated both quantitatively and qualitatively.

Evaluation is a key factor related to the solutions of problems inherent in case studies and is also built into this model. Guba and Lincoln (1988) indicate the axiomatic differences between the rationalistic and naturalistic paradigms for evaluation and these are summarised in Table 3.1. below. This thesis employs both paradigms as the author believes that the two complement each other. In the case of the standard 10 research exercise, a cause-effect relationship (characteristic of rationalistic enquiry) was sought, ie. can the use of the depth perspective used in weather type models result in better conceptualisation which should be reflected in higher test scores. The standard 10 experiment, however, does not provide a full enough picture of the effectiveness of the model-based teaching strategy as it does not probe the constellation of human factors involved; this would be better accomplished by using a naturalist approach such as that used with the standard 9 class.

TABLE 3.1 Axiomatic differences between rationalistic and naturalistic paradigms (based on Guba and Lincoln, 1988)

AXIOMS	RATIONALISM	NATURALISM
Nature of reality	Single, tangible and fragmentable into independent processes and variables. Convergent enquiry suited to hard and life sciences.	Multiple and intangible existing in the minds of people. Divergent enquiry suited to studying human behaviour.
Enquirer-respondent relationship	Enquirer assumes discrete inviolable distance from 'object' of enquiry. Interaction regarded as intrusive.	Denies subject-object independence, they influence one another. Interaction exploited for sake of enquiry.
Nature of truth statements	Nomothetic body of knowledge encapsulated in generalisations. Truth statements are context free. Generalisation makes differences among units intrinsically uninteresting.	Idiographic body of knowledge encapsulated in working hypotheses describing individual cases. Human behaviour is never time or context free, hypotheses work within contexts and are transferable to similar contexts. Differences are as important as similarities.
Causality	Every effect has a cause which can be demonstrated by experiment.	Only patterns of plausible influence can be inferred. Human relationships involve interacting factors, events and processes - searching for cause-effect chains is impossible.
Relation to values	Objective methodology guarantees that enquiry is value free.	Values always impinge on enquiry in terms of: * investigator's selection of problems, theories, instruments, and data analysis modes. * underlying assumptions of the substantive theory guiding the research and of the methodological paradigm. * respondent's values * possible interactions among the above.

The process of evaluating how the standard 9 model-based lessons fared can be termed illuminative and qualitative (characteristic of the naturalistic paradigm), as it attempts to achieve more than evaluation based on the rationalistic model in which only the gains in knowledge made by the pupils are measured quantitatively. The teaching situation involves a complex web of interacting factors, events and processes. The enquirer-respondent relationship cannot therefore be seen as a dichotomy in the rationalistic sense: consequently enquirer-respondent interaction must be exploited if a working hypothesis is to be formulated.

Graves (1975; 1980) identifies several strengths of illuminative evaluation not shared by the traditional input-output (rationalistic) approach: the worthwhileness of the curriculum (or part thereof) is tested; it avoids the difficult and sometimes impossible task of defining precisely the behavioural objectives involved; the unintended outcomes of learning can be accommodated; the fact that geography is in a state of flux, with the result that educational objectives and processes are continually changing, is respected; and, it does not incorrectly assume that all variables (eg. style of teaching, environmental conditions, social psychology) remain the same.

There are other reasons for choosing a qualitative rather than a quantitative approach with the standard 9 class:

(i) In the author's opinion, an experimental approach using a pretest-posttest research design would have been impossible, as there were too many intervening variables. For example, the effect of other educational media (television, videos, magazine articles, etc.) dealing with the learning material may have advantaged some pupils.
(ii) Such a design would not quantitatively prove that the strategy employed was superior to any other.
(iii) The standard 9 class made available by the school for the research exercise consisted of only 12 pupils. Three pupils were absent for one of the two exercises which meant that only nine pupils could be fully accommodated in the research. Because the number of respondents was so small, a qualitative and illuminative research approach was chosen.

Evaluation is concerned with the worthwhileness of various parts and activities of a course. The best type of evaluation for this research would be formative evaluation. In contrast with summative evaluation, which assesses the overall worth of a course from a post hoc stance, formative evaluation is undertaken during a course and is aimed at providing information for the improvement of a program. It provides the researcher with information in order that decisions may be made concerning the suitability of all aspects of a course (Halloway, 1984).

In order to facilitate triangulation a range of research instruments was used to cross reference the research data and included:

(i) Teacher (non-participant) observation schedule and summary,

(ii) Pupil tests to gauge pupil understanding of the lesson,

(iii) Pupil evaluations (questionnaires) of the lessons

(iv) A semantic differential to evaluate pupil attitudes towards the course

(i) <u>Non-participant teacher observation schedule and summary</u>

Systematic observation, also known as process-product research, was first used extensively in the late 1950's and early 1960's to measure classroom processes. Medley (1982) defines systematic observation as the recording of observations of classroom behaviour by a trained observer according to an observation system or scheme. The observation scheme defines the events to be observed and the procedure to be adopted in recording them.

Interaction analysis similar to, but much simpler than that developed by Flanders (<u>in:</u> Medley, 1982), was used. The observation schedule (Table 3.2) was subdivided into two main sections: general information and the use made of the models; and, the verbal inputs made by the teacher and pupils. The non-participant observer ticked those items on the list that he observed during the lessons. By dividing the lesson time up into five-minute periods, the recorder was able to indicate in which period the event took place.

There are three distinct advantages to using such a system. Firstly, it is possible to tell which events occurred during the same five-minute period and which did not; secondly, the recorder's task is simplified as he need only concentrate on the listed items; and thirdly, the recorder's initial training is made easier.

This system of observation also has its disadvantages. Reality is reduced to a few ticks next to a number of prescribed behaviours, thereby handicapping the researcher's later recall of the research situation, especially when the researcher is not the recorder. There is a tendency to concentrate on particular things at the expense of unanticipated evidence (McElroy, 1984). Columns for additional comment by the observer can help to alleviate this problem to a limited extent. A third disadvantage is that the system is only as good as the recorder's observations.

The non-participant observer used the observation schedule to facilitate the completion of an observation summary (Table 3.3). The non-participant observer used a five point rating scale to indicate his feelings on the standard 9 course as a whole. The scale ranged from very weak (1) to excellent (5).

TABLE 3.2 Teacher observation schedule

GEOGRAPHY TEACHER OBSERVATION SCHEDULE

Minutes ------->
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85

SECTION A

1. Reference made to real world
2. Topic definition
3. Use of key concepts
4. Use of models during the lesson:
   - 4.1 iconic
   - 4.2 cross sections
   - 4.3 weather types
   - 4.4 synoptic charts

SECTION B

1. Teacher input:
   - 1.1 questions leading to:
     - recall of facts
     - problem solving
   - 1.2 requiring pupil participation i.t.o:
     - direct observation
     - interpretation
     - application
2. Pupil input:
   - 2.1 information sought i.t.o:
     - clarification of concepts
     - clarification of instruments used
     - other clarification
   - 2.2 questions answered

The summary comprised evaluations of five categories: general aspects, the models used, how the models were used, teacher-pupil interaction, and, the development of skills.

An analysis of the frequencies of each observed item in the schedule, as is normally done when using this observation instrument, was not necessary for the purposes of this research. The schedule was used by the non-participant observer as a guide for the completion of an observation summary. Furthermore, no comparative studies using frequency data from similar situations were envisaged. Had more than one observer participated in the research a test of the reliability of the schedules and summary would have been necessary to ensure that disagreement in recording is kept to a minimum. However, as this study was limited in its scope to only one classroom setting, only one observer was needed and a reliability test was therefore not necessary.

Content validity of the observation schedule and summary is not established statistically, but depends on the opinion of informed persons. Content validity may be defined as the degree to which a test (the observation schedule and summary in this case) succeeds in measuring what it sets out to measure (Mulder, 1987). It involves an item-for-item check of the documents and was conducted in collaboration with the researcher's supervisor to establish whether:

* each item contributed towards the purpose of the

TABLE 3.3 Teacher observation summary

GEOGRAPHY TEACHER OBSERVATION SUMMARY

INSTRUCTIONS

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

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

2. On the right hand side of the ratings column are spaces to record any additional information which you may feel deserves mention concerning each item.

3. Please be frank and as detailed as possible - every piece of information will help to illumine the research area.

A. GENERAL	RATINGS					
1. Reference made to real world situations	1	2	3	4	5	
2. Clarity in defining topic area	1	2	3	4	5	
3. Listing of concepts relevant to the topic	1	2	3	4	5	
B. EVALUATION OF THE MODELS USED (where applicable)						
4. Cross-sectional diagrams:						
Reflection of fundamentals	1	2	3	4	5	
Reduction of noise	1	2	3	4	5	
Visual appeal	1	2	3	4	5	
Enhancement of 3-dimensional aspects	1	2	3	4	5	
5. Synoptic weather maps:						
Reflection of fundamentals	1	2	3	4	5	
Reduction of noise	1	2	3	4	5	
Visual appeal	1	2	3	4	5	
6. The 'weather type' model as a whole:						
Reflection of fundamentals	1	2	3	4	5	
Reduction of noise	1	2	3	4	5	
Integration of climatological concepts	1	2	3	4	5	
Relevance to syllabus	1	2	3	4	5	
Relevance to Southern Africa	1	2	3	4	5	
Potential for conceptualisation	1	2	3	4	5	
7. Iconic models:						
Reflection of fundamentals	1	2	3	4	5	
Reduction of noise	1	2	3	4	5	
Integration of climatological concepts	1	2	3	4	5	
Relevance to syllabus	1	2	3	4	5	
Relevance to Southern Africa	1	2	3	4	5	
Potential for conceptualisation	1	2	3	4	5	
Visual appeal	1	2	3	4	5	
Enhancement of 3-dimensional aspects	1	2	3	4	5	
C. HOW THE MODELS WERE USED						
8. Ease of visibility	1	2	3	4	5	
9. Integration with climatic concepts	1	2	3	4	5	
10. Clarification of distortions in model	1	2	3	4	5	
11. Manipulation of models	1	2	3	4	5	
12. Pupil prediction of changes	1	2	3	4	5	
13. Distinctions made between model and reality	1	2	3	4	5	
14. Stimulation of pupil inquiry/interest	1	2	3	4	5	
15. Respect for differences in pupils' perceptual awareness	1	2	3	4	5	

TABLE 3.3 cont.

D. TEACHER-PUPIL INTERACTION						
16. Pupils:						
Interest	1	2	3	4	5	
Inquiry	1	2	3	4	5	
Spontaneity in answering questions	1	2	3	4	5	
Apparent assimilation of concepts	1	2	3	4	5	
Participation in the lesson	1	2	3	4	5	
17. Teacher:						
Clarity in explanation	1	2	3	4	5	
Clarity in explanation of models	1	2	3	4	5	
Dovetailing of concepts and models	1	2	3	4	5	
Dovetailing of models and synoptic maps	1	2	3	4	5	
Integration of climatological concepts	1	2	3	4	5	
Pitching of lesson at pupils' level	1	2	3	4	5	
Progression from simple to complex concepts	1	2	3	4	5	
D. DEVELOPMENT OF SKILLS						
18. Numeracy	1	2	3	4	5	
19. Graphicacy	1	2	3	4	5	
20. Logicality	1	2	3	4	5	
21. Literacy	1	2	3	4	5	
22. Interpretation of illustrative material	1	2	3	4	5	
23. Application of skills to new situations	1	2	3	4	5	
24. Perception of reality	1	2	3	4	5	
25. Cognitive skills:						
Recall of facts	1	2	3	4	5	
Comprehension (restatement/ reorganisation of knowledge)	1	2	3	4	5	
Analysis (identification of causes, conclusions, supportive evidence, relationships)	1	2	3	4	5	
Synthesis (individualised creative material, predictions, problem solving)	1	2	3	4	5	
Evaluation (opinion based on own judgement)	1	2	3	4	5	

exercise;

* each item is not measuring what has already been covered by another item;
* there are not too many or too few items on a particular aspect;
* all aspects are covered by the items.

(ii) <u>Pupil tests</u>

Objective achievement tests were used in the assessment of the outcomes of pupil learning to establish whether an improvement had occurred in the pupils' understanding of weather types and in their skill in synoptic chart interpretation. The tests were designed to test lower order cognitive skills (recall and comprehension of facts) and higher order cognitive skills (application, analysis and synthesis of information) as found in Bloom's taxonomy (Nowlan, 1990; Stenhouse, 1975). The testing of achievement in the highest order thinking skill, viz. evaluation, was not necessary as personal value judgements are not exercised in synoptic chart interpretation.

Objective tests were used because a wide range of this section of the syllabus can be sampled (Graves, 1975). The major disadvantage of this type of testing is that it is objective only in the marking. As the choice of the questions is subjective, the results from the tests may not be a reflection of whether that part of the syllabus has been grasped.

One short-answer test was completed by the standard 9 class (Table 3.4) to test their grasp of basic concepts related to coastal lows. An essay-type test (Tables 3.5 & 3.6) was completed by both the classes (standards 9 and 10) in an attempt to test the whole range of cognitive skills mentioned above, and, to establish whether the pupils could apply newly acquired knowledge.

TABLE 3.4 Short answer test paper (coastal lows) and answers for standard 9 class

ANSWER MEMORANDUM

EXERCISE ON COASTAL LOWS NAME______________________________

1. Why are coastal lows best developed in winter ?

Anticyclonic circulation is strongly developed/

Strong offshore flow in winter/ (2)

2. Where do they originate and what path do they follow ?

Along the west coast/ They skirt the SA coastline/

They migrate from west coast to east coast/ (3)

3. Describe the weather conditions that occur with the passage of a coastal low.

Ahead of coastal low: Hot/ dry/ berg winds/

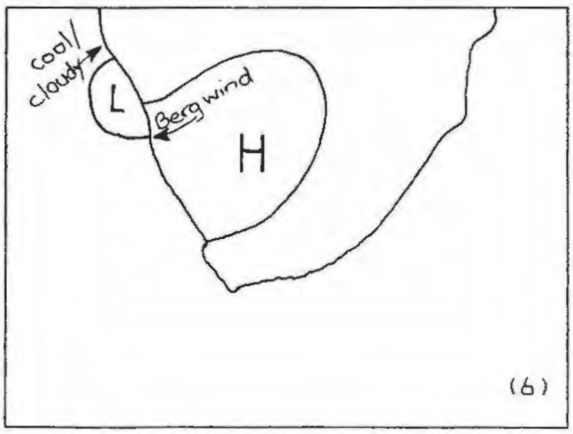
offshore flow/

Behind coastal low: Cool/ cloudy/ onshore flow/ (7)

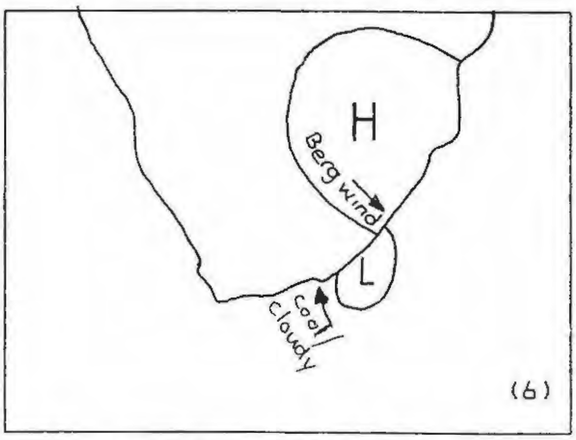
4. What changes in weather can be expected to follow within hours of the passage of the coastal low?

Cold snap (1)

5. Complete the rough synoptic maps below by drawing in the isobaric patterns to show a coastal low situation : a) at its point of origin; and b) along the eastern Cape coast a few days later. Do not write in isobaric values, simply indicate high and low pressures with H and L, and wind directions and their characteristics.



Point of origin

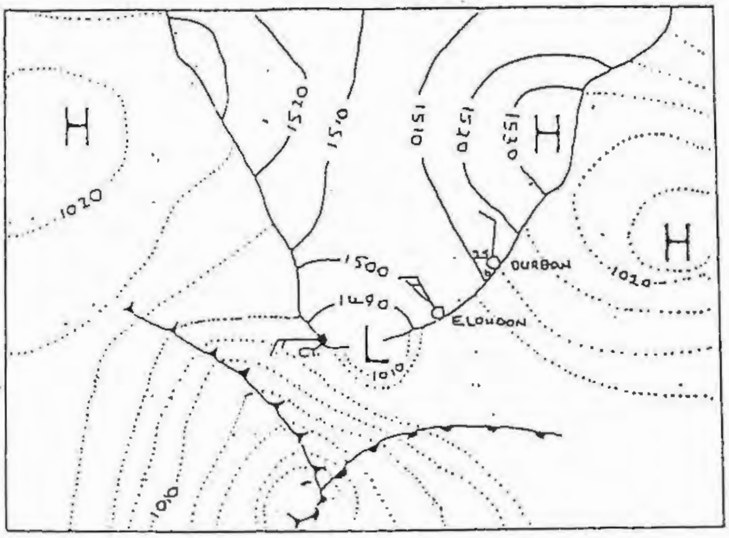


Along eastern Cape coast

TABLE 3.5 Essay-type test paper (consolidation exercise) and answers for standard 9 class

CONSOLIDATION EXERCISE NAME ______________________

Study the synoptic chart and answer the question that follows.



Describe and explain how the weather conditions will change over the next 48 hours in East London.

ANSWER MEMORANDUM [30 MARKS]

Ahead of coastal low:
Berg winds/ owing to offshore flow/ down escarpment/ hot/ dry/ cloudless/ adiabatic heating/ decrease in pressure with onset of coastal low/

Behind coastal low:
Onshore flow with trailing edge of coastal low/ cooler/ moister/ cloudy/ possible drizzle/ veering wind/ cirrus cloud / heralds approach of cold front

Passage of cold front:
Increase in pressure followed by fall/ wind backs from NW to SW as front passes/ humidity increases/ temperature falls/ drop in RH as cold sector passes/ cumulonimbus/ cold snap/ storms/ snow / pressure rise/ clearing from W/

[25 FACTS + 5 FOR STYLE = 30]

TABLE 3.6 Essay-type test paper (Winter circulation) and answers for standard 10 class

CANDIDATE'S NUMBER

PUPIL WORKSHEET FOR WINTER CIRCULATION UNIT

INSTRUCTIONS

1. This is not a test that counts for marks. The results are to be used in research.
2. Please do not indicate your name - anonymity and confidentiality will be maintained.
3. Please answer the following question as fully as possible without using diagrams in your answer.
4. You have 10 minutes to complete the exercise.
   Thank you for your co-operation and valuable contribution.

QUESTION : Why are winters over the highveld of southern Africa associated with dry conditions.

ANSWER MEMORANDUM [20 MARKS]

Anticylonic circulation dominant in winter/ S. Atlantic high, S. Indian high and Kalahari high form continuous belt of high pressure/ Kalahari high strengthens/ exerts influence down to plateau level/ Air subsides/ heats up adiabatically/ dries out/ becomes stable/ creates inversion layer across sub-continent/ Air cannot rise to form deep cloud/ Inversion layer acts as plug/ and keeps moist maritime air from being advected over the escarpment/ Drought prevails.

[15 FACTS + 5 FOR STYLE = 20]

In the marking of the essay-type answers, the reproduction of facts contained in the worksheets did not necessarily show that the pupils understood the lesson unit. It was therefore decided that the use of concepts would have to be scrutinised to ascertain whether the weather type models aided the pupils' understanding or not.

(ii) Pupil evaluations of the lesson

Towards the end of each of the two standard 9 lessons, the pupils were required to complete an evaluation of the lesson using a three point rating system (Table 3.7 below). The role of the pupils in the evaluation of action research is justified, as they are the participant clients for whom the study has been devised. As the clients, their approval or disapproval provides an insight into the process from yet another view-point as was pointed out earlier in the context of triangulation as a research technique.

An important drawback of the evaluation schedule is that the responses from the pupils are 'patterned' by the questionnaire, so that the freedom of the respondent to express his opinions fully, is restricted. This limitation is not confined to evaluation schedules alone. Any form of evaluation follows a predetermined format, and this includes evaluation by interview. An interview was not practicable because of time limitations associated with the running of the school - the researcher had only two lessons in which to

TABLE 3.7 Pupil evaluation of the lesson on coastal lows

PUPIL EVALUATION OF TEACHING UNIT ON COASTAL LOWS

STANDARD________ GRADE (HG or SG)_______ AGE____yrs ____mths

This is a questionnaire and not a test - there are no correct or incorrect answers. Please be totally honest in your response.

PART ONE

1. Please indicate your feelings on the lesson by circling the appropriate rating in the column next to each question.

2. The ratings to be used are:

   1 = Not at all
   2 = Partially
   3 = Fully

   For example,

To what extent did you enjoy the lesson ?	1	(2)	3

   means that you partially enjoyed the lesson.

QUESTIONS	RATINGS		
To what extent :			
1. did the models aid your understanding of coastal lows?	1	2	3
2. did the cross sectional diagrams aid your understanding of coastal lows ?	1	2	3
3. did you understand the notes (key facts) ?	1	2	3
4. do you feel confident about interpreting coastal low low information from a synoptic chart ?	1	2	3
5. have you grasped the following concepts:			
low pressure cells ?	1	2	3
high pressure cells ?	1	2	3
offshore flow ?	1	2	3
onshore flow ?	1	2	3
berg wind ?	1	2	3
advection ?	1	2	3

To what extent:			
6. did you understand the lesson as a whole ?	1	2	3
7. did the lesson interest you ?	1	2	3
8. did you enjoy the lesson ?	1	2	3
9. did you find the lesson clear ?	1	2	3

PART TWO

1. Which part of the lesson did you find:

   1.1 most interesting ? ____________________

   1.2 most boring ? ____________________

   1.3 easiest to understand ? ____________________

   1.4 hardest to understand ? ____________________

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

Thank you for your co-operation and valuable contribution.

conduct the whole exercise.

The overall results, derived from the pupil evaluations, were then compared to those derived from other sources such as the semantic differential and the observation schedule and summary. In this manner a degree of methodological triangulation, or what Denzin (in: Cohen and Manion, 1989:274) refers to as 'between methods triangulation' was achieved.

(d) The semantic differential

The semantic differential is a technique used to measure the meaning a concept has for different people and is frequently used to measure attitudes in research (Adams, 1982; Oosthuizen, 1986). It is grounded in the idea that meaning is given within a definite semantic space. (Figure 3.2). Using factor analysis, Osgood (1976) identified three factors or dimensions within the semantic space, viz. evaluation, potency and activity. According to Dane (1990) the evaluation dimension has a bearing on the overall positive or negative meaning attached to a concept, potency refers to the overall strength or importance of the concept, and activity refers to the extent to which the concept is associated with action or motion.

The three dimensions may be represented as axes within the semantic space (Figure 3.2 below) which determine the nature and quality of the meaning given. The positions that the meanings assume on the various axes indicate the intensity or quality of those meanings (Van den Aardweg & Van den Aardweg, 1989; Vrey, 1979).

Oosthuizen (1986) argues that an interesting parallel is inferred (though not yet empirically researched) between Osgood's evaluative, potency and activity factors and the categories of significance (or meaning) attribution, experience and involvement respectively.

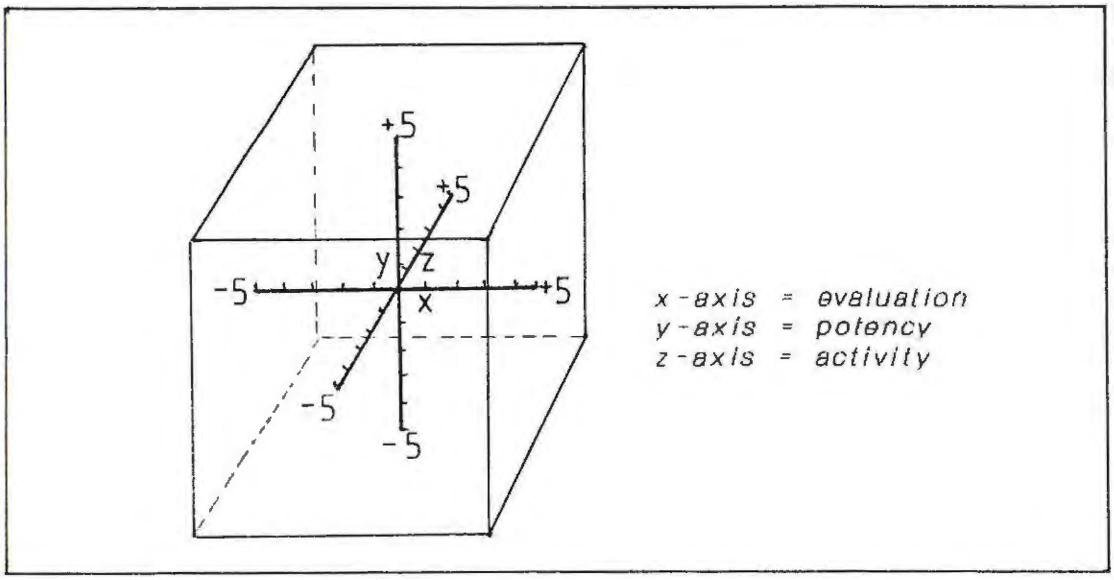


FIGURE 3.2 The semantic space showing Osgood's dimensions (after Oosthuizen, 1986)

Significance attribution focuses on the cognitive domain, ie. knowing, recognising, naming, understanding and applying. It implies that the nature and quality of relations with something or someone are determined by the meaning or significance assigned. Experience can be described as the intentional, definite, subjective and personal stance of a person in his communication with reality and consists of the affective dimension. Through experience, the potency or varying degrees of pleasantness or unpleasantness of a situation is evaluated. Involvement may be defined as the person's concern with a particular situation which prompts him to act and it is distinguished by conative action.

By using the above mentioned categories as the axes in the semantic space, the researcher was able to gauge how meaningful the model-based lessons were to the standard nine pupils by having them rate their feelings along continua between opposite adjectives (Table 3.8 below). Each pupil was asked to rate his position with respect to word pairs related to the course and representing the three categories of experience, involvement and significance attribution. The rating chosen provided a score between 1 and 5 which serves as a measure of the degree of negativity or positivity that the pupil attached to each item. Rating scores could then be totalled and averaged to provide a clearer picture of the overall impact of the lessons on the pupils.

<u>The action research procedures</u>

In accordance with Elliott's action research model, this section deals with the implementation of the action steps. The monitoring of that implementation and its effects are described.

The researcher visited one East London school to gauge the

TABLE 3.8 Semantic differential on pupils' attitudes towards the standard 9 course

PUPILS' ATTITUDES TOWARDS THE COURSE

STANDARD_____ GRADE (HG or SG)____ AGE____(yrs)____(mths)

INSTRUCTIONS

1. Please indicate the intensity of your feelings towards the course on coastal lows and mid-latitude depressions by drawing a circle around the number that expresses those feelings best.

   For example:
   I associate the course with the following:

Boring	(1)	2	3	4	5	Interesting
Illogical	1	2	3	4	(5)	Logical
Difficult	1	2	(3)	4	5	Easy

   indicates that the course was boring, logical and neither too difficult nor too easy.

2. Please be totally honest - this is not a test, there are no right or wrong answers.

3. Your name is not required.

I associate the course with the following:

Unpleasantness	1	2	3	4	5	Pleasantness
Tension	1	2	3	4	5	Relaxation
Frustration	1	2	3	4	5	Fulfillment
Failure	1	2	3	4	5	Achievement
Dissatisfaction	1	2	3	4	5	Satisfaction
Boredom	1	2	3	4	5	Interest
Difficult	1	2	3	4	5	Easy
Passive involvement	1	2	3	4	5	Active involvement
Undemanding	1	2	3	4	5	Challenging
Rejection of content	1	2	3	4	5	Identification with content
Illogical	1	2	3	4	5	Logical
Vague	1	2	3	4	5	Clear
Unintelligible	1	2	3	4	5	Intelligible
Irrelevant	1	2	3	4	5	Relevant
Unrealistic	1	2	3	4	5	Realistic

Thank you for your co-operation and valuable contribution.

effectiveness of a model-based teaching and learning strategy with senior secondary geography pupils. Two classes were used in two different research designs:

1. A standard 10 class was used to test whether one particular weather type model, devised by the researcher, helped as a learning device in the assimilation of S.A. climatological concepts.
2. Two other weather type models were taught by the researcher to a standard 9 class with the class teacher observing the lesson as non-participant observer.

Procedure for the standard 10 class

According to Van den Aardweg and Van den Aardweg (1989) experimental research is used to test an hypothesis by means of carefully controlled conditions in which the effect of a manipulated independent variable is observed while all other variables are held constant where possible. The hypothesis tested was that pupils are better able to assimilate climatological concepts through using depth perspectives or schematic cross-sections than those pupils who do not. This design requires that an experimental group (using the depth perspective) and a control group (not using the depth perspective, but in which all factors are identical to those in the experimental situation) be used. Any difference in the learning results between the two groups should be due to the introduction of the specific variable (the depth perspective).

A standard 10 class of 22 boys of mixed ability was divided into two matched groups of similar ability. Matching was done on the basis of intelligence quotients (Table 3.9 below) as marks on past performance in SA climatology were not available. The experimental group was then chosen by flipping a coin.

TABLE 3.9 Matched intelligence quotients of pupils in groups A and B

PAIR	GROUP A	GROUP B	PAIR	GROUP A	GROUP B	PAIR	GROUP A	GROUP B
1	133	136	5	113	114	9	104	106
2	121	119	6	113	113	10	102	100
3	116	117	7	111	112	11	84	88
4	116	114	8	108	107			

There are limitations to the use of matching pupils according to intelligence quotients. The most well known intelligence tests, such as the Stanford-Binet test, are not perfectly reliable. Biehler (1981) states that the various intelligence tests used to measure intelligence quotients are based on different assumptions. Van den Aardweg (1989) claims that innate intelligence cannot be measured by these tests because intelligence has not yet been defined. Research conducted by Bayley (<u>in:</u> Biehler, 1981) suggests that considerable variability in IQ scores occurs. Biehler states that children tested every two years between the ages of six and eighteen can reveal scores that vary by fifteen points or more. This variability therefore limits the reliability of t-test results derived from samples matched on the basis of intelligence quotients.

The research design employed in the exercise can be symbolically represented as follows:

$$Mr \; \frac{X_1 \quad Y}{X_2 \quad Y}$$

where Mr = two groups matched according to IQ ratings

X = the group that uses a weather type model

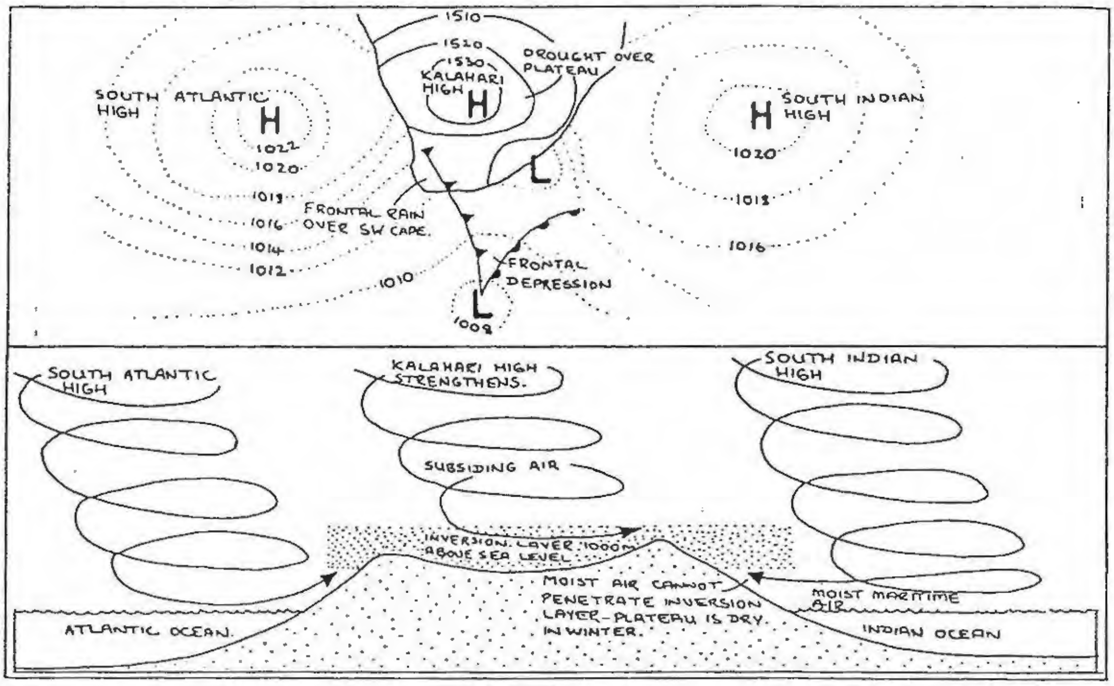
X_2 = the group that does not use a weather type model

Y = both groups write the same test

Each group was given learning material on winter circulation over southern Africa, but while group B was given a synoptic chart and key notes only, group A was given a schematic diagram in addition to the synoptic chart and key notes (Figure 3.3 below). The groups were given 15 minutes to peruse the learning material. They were then allocated 10 minutes to complete a common test (Table 3.6) in which they had to complete a short essay-type question requiring an understanding of the facts and concepts in the learning material. They were not allowed to use illustrative material in their answers. (Table 3.6 also contains the answers to the questions).

A t-test for matched data was used to test the scores of the pupils in the two groups to ascertain whether there was a significant difference between the arithmetic means of the two groups. The results of this test appear in Chapter 5.

8. WINTER CIRCULATION



KEY FACTS

1. Anticyclonic circulation dominates southern African weather in winter.
2. The South Atlantic high, the Kalahari high and the South Indian high intensify and form a continuous belt of high pressure over the sub-continent.
3. The Kalahari high exerts its influence down to approximately 1000 metres above sea level (ie below plateau level).
4. The subsiding air of the anticyclone heats up adiabatically creating an inversion layer in which temperature increases with height so that air cannot rise (ie stable air) and drought prevails.
5. The inversion layer acts as a barrier and prevents moist maritime air from crossing the escarpment.
6. Deep clouds cannot form over the plateau because of the subsiding air of the Kalahari high and because of the absence of moist maritime air.
7. A marked diurnal temperature range exists - days are normally clear and mild, while nights are cold and frosty because of the absence of cloud cover which allows terrestrial radiation.
8. The SW Cape and the southern coastal areas are periodically invaded by frontal depressions resulting in rain and occasional snow over high-lying areas.
9. Berg winds are most frequent in winter (April to September). They occur along the coast with the approach of a cold front.

FIGURE 3.3 Key notes and diagrams used with the standard 10 class

Procedure with the standard 9 class

The author, as participant observer, taught two lessons on weather types based on the weather type models in chapter 3, viz. coastal lows and mid-latitude depressions. A variety of other models, such as polystyrene representations of a frontal depression and meteosat photographs, were also used.

An attempt was made to proceed from the real world to an iconic representation and then to a symbolic representation of the coastal low and mid-latitude depression.

The teacher of the class, who was also the head of the geography department, observed the lessons as non-participant observer and was guided in his observation by using an observation schedule (Table 3.2). At the end of the two lessons, his feelings on the lessons and the model-based strategies used, were reflected in an observation summary (Table 3.3).

At the end of each lesson the pupils completed a test (Tables 3.4 and 3.5) to provide an indication of the extent to which the lesson material was understood.

The pupils finally completed a two part evaluation of the lesson by rating their feelings and also providing other information not covered by the ratings (Table 3.7). The researcher used this technique instead of structured interviews for two reasons:

(i) A formal structured interview is time consuming. All standard nine pupils at the school were due to write tests on a fairly wide area of the climatology syllabus. To have asked the teacher for two extra periods to conduct the interviews on the two lessons, would have been an imposition on his teaching schedule and would have disadvantaged the pupils in the test.

(ii) This technique is well suited to gauging the feelings of an entire class in a semi-structured manner, which is neither as time consuming nor as rigid as a formal structured interview.

The nine pupils who were present for the whole course finally completed a semantic differential (Table 3.8) at the end of the course to rate their feelings in respect of their experience of, their involvement in and the meaning they attributed to the course.

3.5 SUMMARY

As this study sought solutions to ethnographic problems, an action research approach was used. Elliott's action research spiral was used as a framework, and, as the study was a pilot study, only one cycle was employed. In the first stage of the research, pupil difficulty in the reading and interpretation of synoptic charts was identified as the problem, and, the methodology used in the design of strategies to alleviate these problems was set out. The second stage of the research involved the testing of the use of the weather type models in two settings. In the first setting, a quantitative research design was used with a standard 10 class. In the second setting, use was made of a qualitative approach involving a case study application of action research with a standard 9 class. The action research procedures, in which achievement tests, evaluation schedules, an evaluation summary, and a semantic differential were used, were then outlined.

CHAPTER 4

THE WEATHER TYPE MODELS

The factors which exacerbate the problem of teaching S.A. climatology, such as perceptual and conceptual problems, syllabus fragmentation, temporality and lack of continuity have been dealt with elsewhere. The weather type models discussed in this chapter were devised in an attempt to alleviate those problems and formed part of the research procedure relating to Elliott's action research model (Chapter 3).

This chapter is concerned with:

1. The characteristic features of the weather type models.
2. The purpose of the models.
3. The place of weather type models in the S.A. syllabus.
4. How the models were devised.
5. The value of the models.
6. The theoretical weather type model used with supporting material as a progression framework for conceptual development.

4.1 THE CHARACTERISTICS OF THE WEATHER TYPE MODELS

The concept 'weather type model' was discussed in Chapter 2, where it was stated that weather type models represent generalisations of repeating weather patterns designed to predict future patterns. Each type of representation offers a generalisation of the pertinent aspects of a particular weather type and can be used as a tool to understand the climatological processes involved in that particular weather phenomenon. It was also established that weather type models embrace both theoretical models and hardware models. The emphasis in this chapter falls on the former.

Each of the theoretical weather type models follows a similar three part format in keeping with the idea that instruction should proceed from the familiar and pass through degrees of abstraction towards the symbolic. The models begin with annotated side views or cross sections through weather systems. A plan view in the form of a simplified synoptic chart with explanations is then provided. The third part of the theoretical model is made up of key facts and attempts to encapsulate all the information associated with the weather type.

4.2 THE PURPOSE OF THE MODELS

The purpose of the theoretical weather type models is to facilitate:

(i) the teaching of climatological concepts and their interrelationships in the context of synoptic chart interpretation, and,

(ii) the improvement of graphicacy skills which are specifically related to the properties of maps.

More specifically, the objectives of the weather type models are:

(i) To establish the major components that comprise southern African weather patterns or types.

(ii) To teach these components in a progressive manner from simple types to composite types.

(iii) To facilitate the three-dimensional visualisation of two-dimensional representations.

(iv) To establish and consolidate climatological concepts through the medium of the synoptic chart.

(v) To interpret synoptic charts.

(vi) To provide concise summaries of the weather types.

It must be stressed that the weather type units are not ready-to-teach lessons, but are intended for use as both an instructional aid for teachers and a learning aid for pupils.

4.3 THE PLACE OF THE WEATHER TYPE MODELS IN THE S.A. SYLLABUS

After studying a number of matriculation examination papers, the Cape Education Department syllabus and secondary school text books such as Juta's New Window on the World series and Nasou's Senior Geography series, it became clear to the researcher that many of the weather systems could be classified into weather-types. Valuable background information and pictorial ideas were gleaned from Strahler (1963); Hurry & Van Heerden (1982); Eyre & Gower (1983); Wright (1983); Grenyer (1985); Atkinson & Gadd (1986); Knapp

(1986); Graves, Lidstone & Naish (1987); Bond (1989); Porter (1989) and Earle & Bagnall (1990).

The climatology section of the matriculation examination papers tended to focus on either a summer or a winter synoptic pattern. Such composite patterns or types involve the interaction of high and low pressure systems, and in fact, even the single types are associated with either high or low pressure systems. A carefully planned sequence of weather types and related concepts (Table 4.1 below) was designed to aid the progressive development of theoretical weather type models ranging from single types to composite types.

Progression implies an advance in understanding and performance, (Bennetts, 1981). The table below (Table 4.1) attempts to identify the conceptual progression which ought to be considered in the teaching of weather types in the S.A syllabus. Five groups of weather patterns subsuming ten weather types are identified. The continental and maritime anticyclonic circulation patterns are classified in the table as the simplest types. Cyclonic circulation manifests itself in at least four forms and they are ordered in the table according to their degree of complexity, viz. the heat low (simplest manifestation), the coastal low, the frontal or mid-latitude depression, and the tropical depression (most complex manifestation). The third pattern combines elements

TABLE 4.1 The weather types and related concepts

	Weather types	Concepts
Single weather types (simple) ↓	Anticyclonic circulation — over land; — over ocean	Atmospheric pressure, isobar, subsidence, divergence, stability, adiabatic warming, advection, South Indian , South Atlantic and Kalahari highs.
	Cyclonic circulation — heat low; — coastal low; — frontal depression; — tropical depression	Convergence, rising, unstable air, offshore and onshore air flow, berg wind, cold and warm fronts and sectors, backing wind, cloud types, occlusion, hurricane, eye of cyclone, dangerous semicircle, fog.
	Ridges and troughs	Revision of concepts from former units
	Winter circulation	Revision of and incorporation of a number of former concepts and units Also inversion layer, drought.
composite weather types (complex)	Summer circulation — general; — thunderstorms	Revision of and incorporation of a number of former concepts and units Also moisture front, line thunderstorms and migration.

from the former and comprises ridges and troughs. The most complex types represent seasonal circulations, viz. winter and summer circulations. The summer circulation patterns can be examined at different levels: on the macro-scale as a general type, or on a local scale where one aspect or sub-type within the general type (in this case the thunderstorm) is focussed upon.

In the next section theoretical weather type models ranging from single types to composite types are presented within the groupings identified in Table 4.1.

4.4 HOW THE WEATHER TYPE MODELS WERE DEVISED

According to Ellington (1985), there are three basic classes of instructional methods. The most commonly used is that class that employs mass instruction techniques in which the teacher assumes a traditional expository role and controls the instruction process. The second class embraces individualised instruction, such as directed study and programmed learning, in which the teacher acts as producer/manager of the learning resources and as a tutor and guide. Group learning comprises the third class in which the teacher organises and facilitates group exercises such as tutorials, seminars, and games and simulations.

The weather type models were designed with the first class, mass instruction, in mind. The reality of the classroom in most South African schools is that mass instruction is the most commonly used method, whatever the reasons or disadvantages might be. Admittedly, the mass instruction technique cannot accommodate a differentiation in the various learning styles and rates of learning, but it remains, nevertheless, the most popular method of instruction in most educational institutions (Ellington 1985).

In the units on anticyclonic circulation anchorage ideas learnt in earlier years (eg. subsidence, divergence, direction of air flow) are used, and these concepts are illustrated using cross-sectional or depth views and are also included in the synoptic chart. In this manner, progression from simple anchorage ideas familiar to the pupil, to newer and more complex ideas, is achieved, and, the abstract representation of those ideas using a synoptic chart is implemented.

The anticyclonic types

There are three reasons for commencing with the units on anticyclones:

(i) Because the average condition of the atmosphere over southern Africa can be described as stable as a result of its position in the belt of sub-tropical highs (Tyson, 1986; Preston-Whyte & Tyson, 1988), a unit on anticyclonic circulation would be the logical place to start such a series of studies.

(ii) Owing to the greater spacings between its isobars, the anticyclone's isobaric configuration on a synoptic chart is

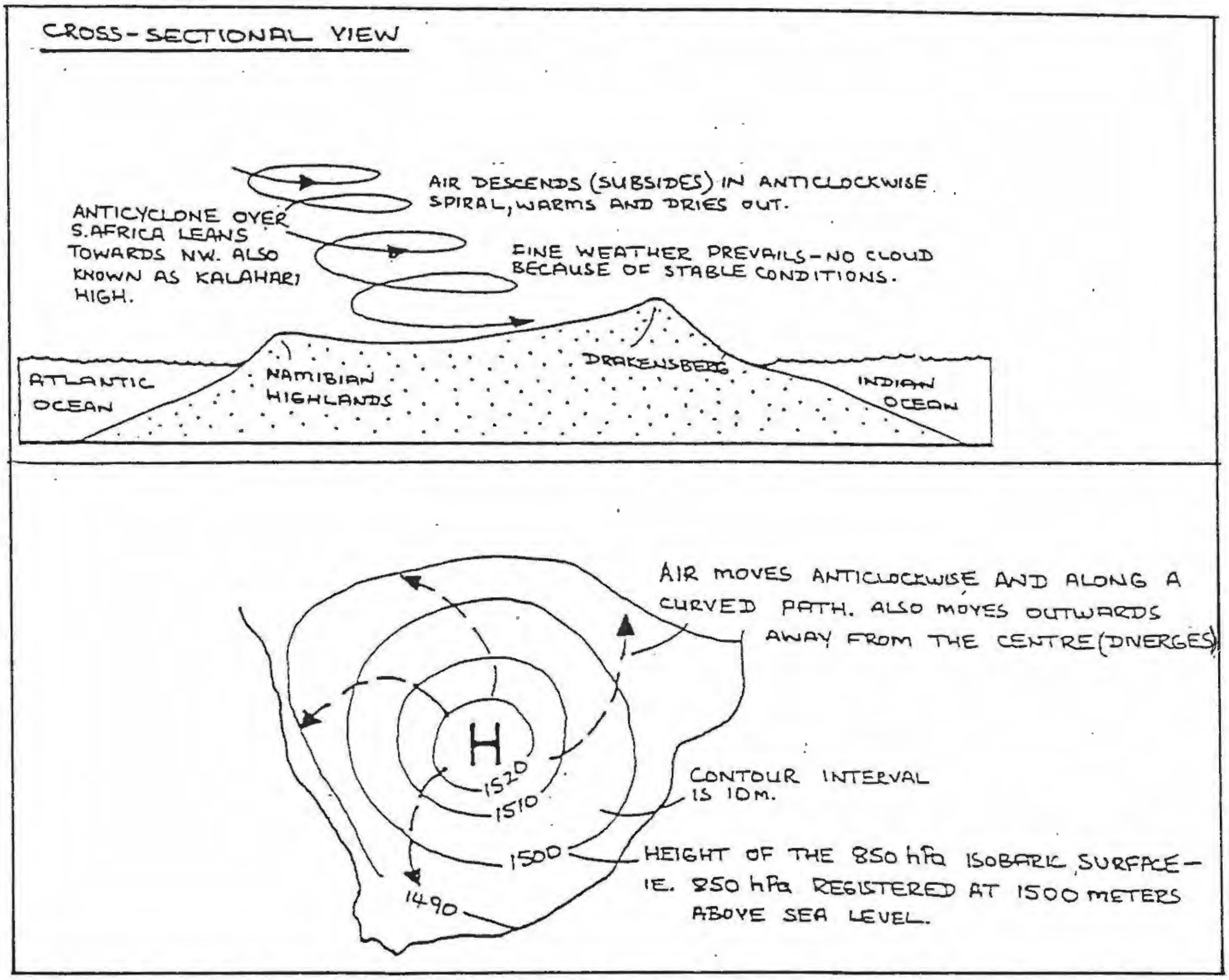
relatively clear, simple and uncluttered in its symbolic representation. The task of introducing the pressure cell (upon which rests the further understanding of synoptic chart interpretation) to the beginner is therefore made easier.
(iii) The anticyclone is a relatively easy concept to proceed from, as it does not vary to any marked extent in its form. This is not the case with cyclones, which range from something as small and short-lived as the tornado, through to the vast and complex frontal depression with its life span of many days.

Anticyclonic circulation does, however, manifest a seasonal variation with respect to latitudinal and altitudinal position. The writer distinguishes between anticyclonic circulation over the land (Figure 4.1) and that over the sea (Figure 4.2), because there is a difference in the roles that these two types of anticyclone play in southern African climate. For example, unlike the South Atlantic and South Indian anticyclones the effect of the high pressure cell over the sub-continent (also known as the Kalahari high) is not always felt at surface level in the summer months; the anticyclones over the oceans are responsible for the supply of moist air over southern Africa, whereas rainfall distribution and intensity over the land is largely determined by the fluctuating behaviour of the Kalahari high. The first weather type model introduces the concept of the anticyclone in the context of the Kalahari high over southern

Africa. A side view illustrates the processes of anti-clockwise spiralling, subsidence and divergence and the anticyclone's proximity relative to the land surface and the subcontinent. The plan view is a synoptic chart representation and reveals the anticyclone's areal extent, its associated contour spacings and anticlockwise movement of air. The use of height contour lines to express the 850 hPa isobaric surface is also introduced. The key facts endorse what is portrayed in the diagrams. An attempt is made to impress on the pupil the fact that anticyclonic circulation over the land is characterised by fair conditions.

The second model proceeds to a study of the maritime anticyclones, viz. the South Indian and the South Atlantic highs. Their location relative to the sub-continent and the two dominant ocean currents are shown in the side view, and elements from the previous model are revised in this new context. Advection and the moisture and temperature characteristics of the advected air are introduced for the first time. The plan view represents in a synoptic chart format much of what the side view shows. The use of isobars over the sea, their spacings, and their values are shown. The key notes encapsulate the aforegoing in the context of the two anticyclones.

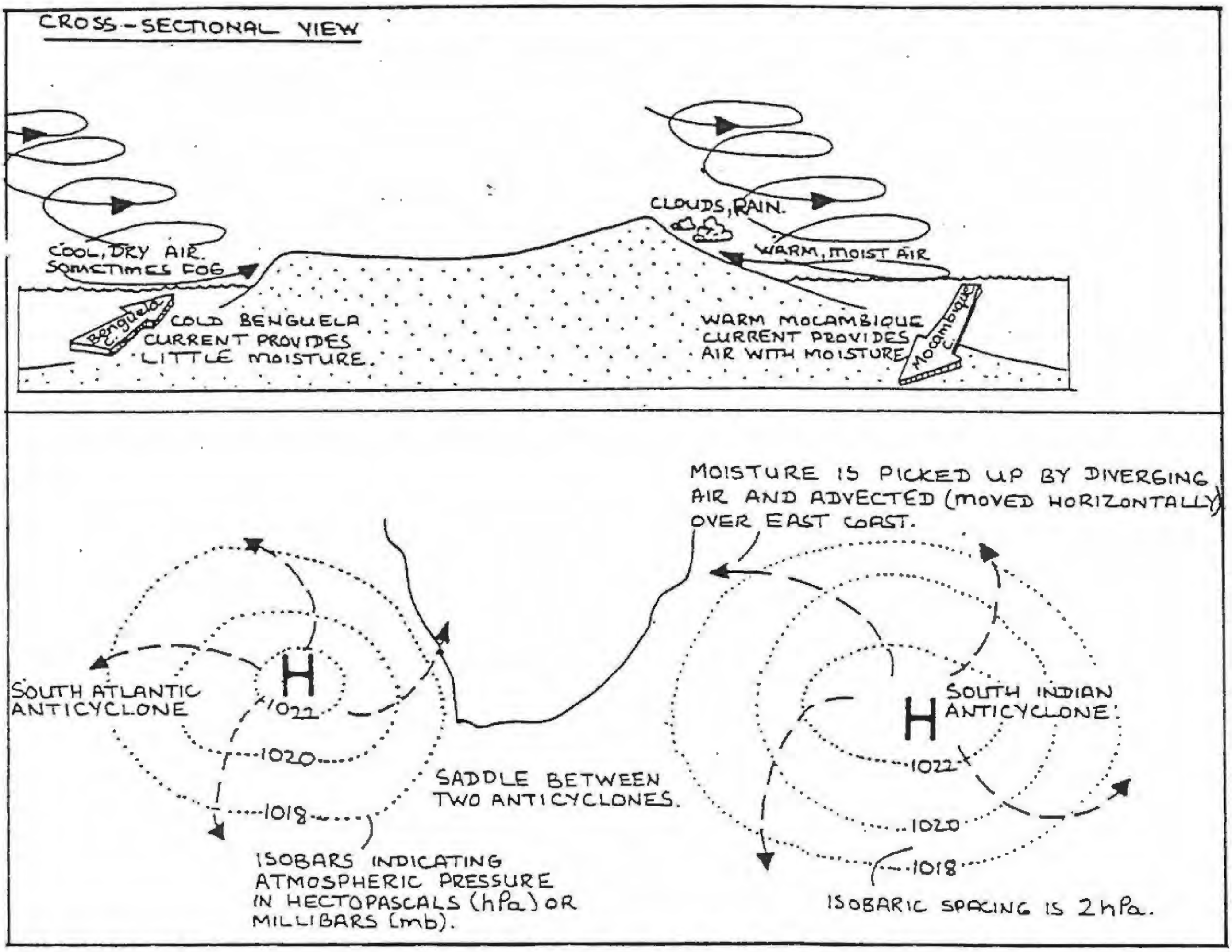
In both models the seasonal variation and influence of the anticyclones on southern African climate is pointed out.



KEY FACTS

1. Anticyclones are high pressure cells - they are also called highs.
2. They dominate southern African weather in winter.
3. Air moves anticlockwise around them in the southern hemisphere.
4. Anticyclonic air descends (subsides), warms and dries out.
5. Anticyclonic air is stable (does not have a tendency to rise), cloud fomation is therefore limited.
6. Subsiding air spreads out (diverges) at the surface.
7. Anticyclonic circulation is associated with cold, frosty and clear conditions in winter.
8. Anticyclonic circulation over southern Africa weakens in summer - the Kalahari high does not always extend its influence down to plateau level in summer.
9. The isolines over the land are height contours indicating the altitude at which 850 hectopascals (hPa) is measured.

FIGURE 4.1 Unit 1: Anticyclonic circulation over the land



KEY FACTS

1. Anticyclones strengthen in winter and weaken in summer.
2. The South Indian high moves away from the east coast in summer in a SW direction. Its outer edge then advects moist NE air over the eastern parts of the sub-continent in summer and derives its warmth and moisture from the warm Mocambique current.

   The South Indian high moves towards southern Africa and strengthens (intensifies) in winter.
3. The South Atlantic high does not change its position markedly from season to season.

   It causes cool, dry SW air to blow over the western parts as it is influenced by the cold Benguela current.
4. The isolines over the sea on a synoptic map are isobars.

FIGURE 4.2 Unit 2: Anticyclonic circulation over the sea

The cyclonic types

In this group of weather type models, the term 'cyclone', denoting a low pressure cell, was deliberately avoided as much as possible because of the layman's tendency to equate 'cyclone' with a hurricane. Instead, the terms 'low' and 'depression' are used.

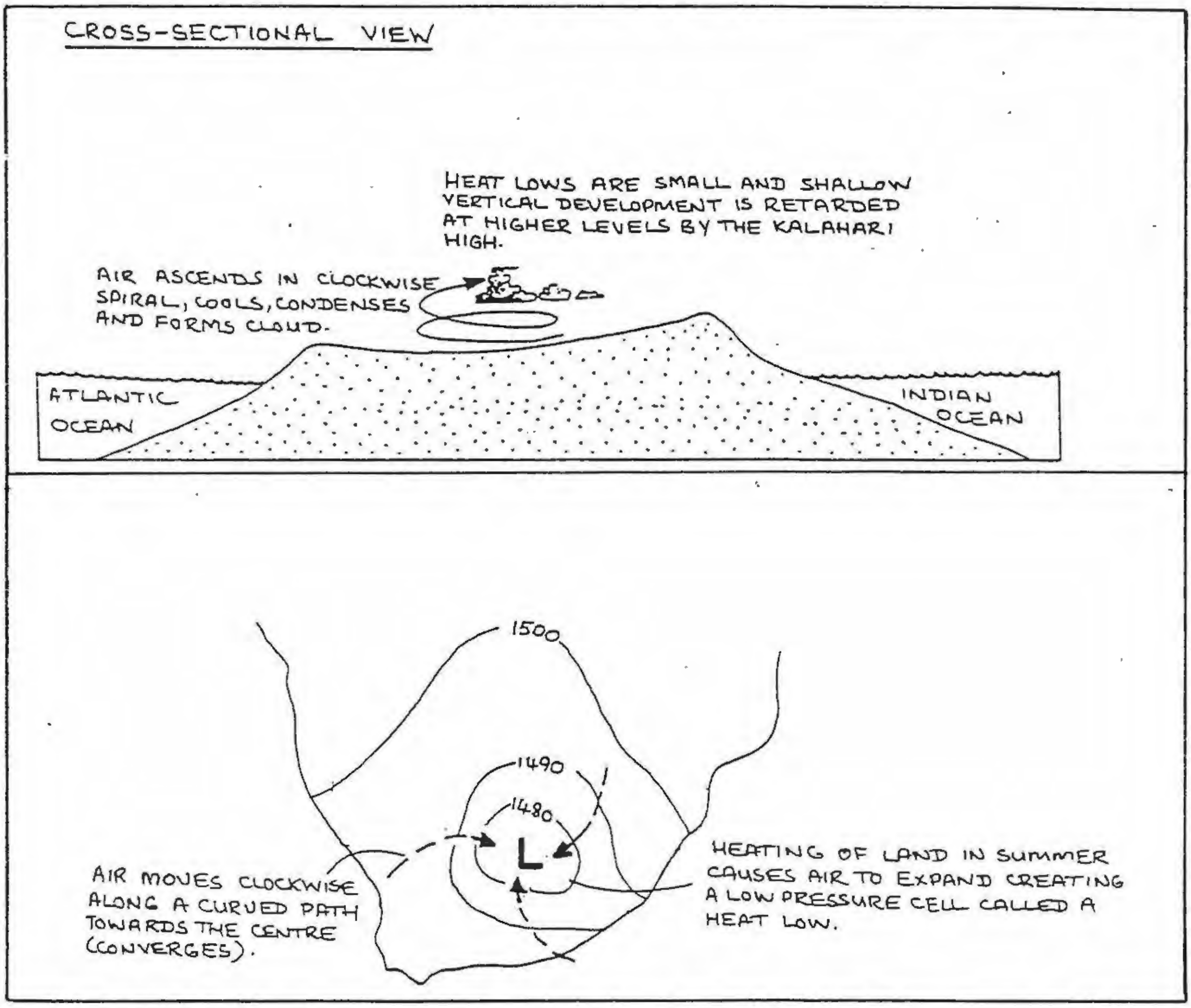
The theoretical model on the heat low (Figure 4.3) is perhaps the simplest of all the cyclonic types. The plan view introduces the ideas of convergence and clockwise ascent of air and the association of cyclonic circulation with cloud formation. The shallowness of the heat low is also portrayed. The plan view is a simple synoptic representation of the side view and illustrates the curved path taken by the converging air as well as the areal extent and position of the low. The key facts point out the seasonal influence of the Kalahari high on the development of the heat low and distinguish the heat low from other depression types.

The mastery of the coastal low goes beyond the examination of a single simple isobaric pattern. Interrelationships between separate systems, viz. an anticyclone over the land and a low over the coast, are introduced to explain the berg wind (Figure 4.4) In this way principles, which state a predictable relationship between concepts, are taught. As the passage of a coastal low is characterised by two-phase weather, it was necessary to include a diagram showing the depth perspective.

The migration of the low around the sub-continent introduces a complicating factor in its visual portrayal. This weather type is best taught using models such as those shown in Figures 4.11 and 4.14. This weather type unit is presented in the usual side view and plan view format, it revises the concepts encountered previously and preludes the following unit on frontal depressions.

The problem of conveying the idea that synoptic patterns are not static has been considered in the model of frontal depressions (Figure 4.5). Two consecutive synoptic charts are used to give the pupil an idea of the dynamic and ever-changing state of weather systems. The pupil is introduced to the concepts of cold and warm fronts, frontal rise, air sectors, backing winds, cumuliform and stratiform clouds, and occlusion. Elements from the previous unit on coastal lows are knitted in to provide continuity between the weather types.

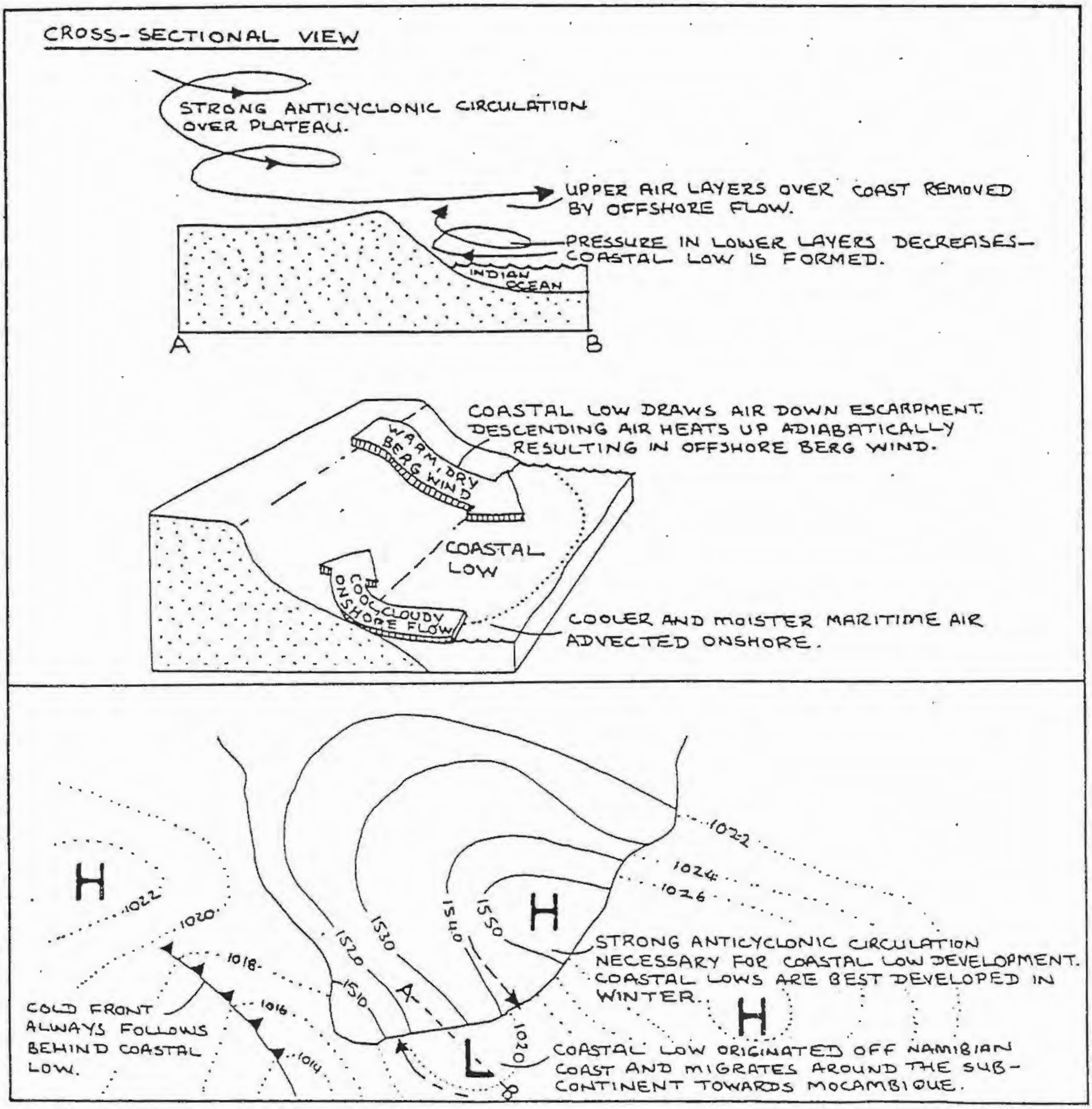
In the tropical depression model (Figure 4.6) the pupil encounters a graph showing changes in wind velocity and pressure experienced with the passage of the hurricane. The graph is often used in text books and examinations, and is a good vehicle for displaying interrelationships in order that a deepening as well as a widening of understanding is achieved.



KEY FACTS

1. Cyclones are low pressure cells - they are also called lows.
2. The term depression is preferable to cyclone - the term cyclone pertains to a hurricane.
3. Air moves clockwise around a depression in the southern hemisphere.
4. Cyclonic air converges (comes together), rises, cools and condenses to form clouds and is associated with precipitation.
5. Cyclonic air is unstable (it has a tendency to rise).
6. Heat lows only occur in summer when the Kalahari high does not extend down to plateau level.
7. The heat low is only one example of a variety of depressions - others include coastal lows, mid-latitude depressions, tropical depressions and cut-off lows.

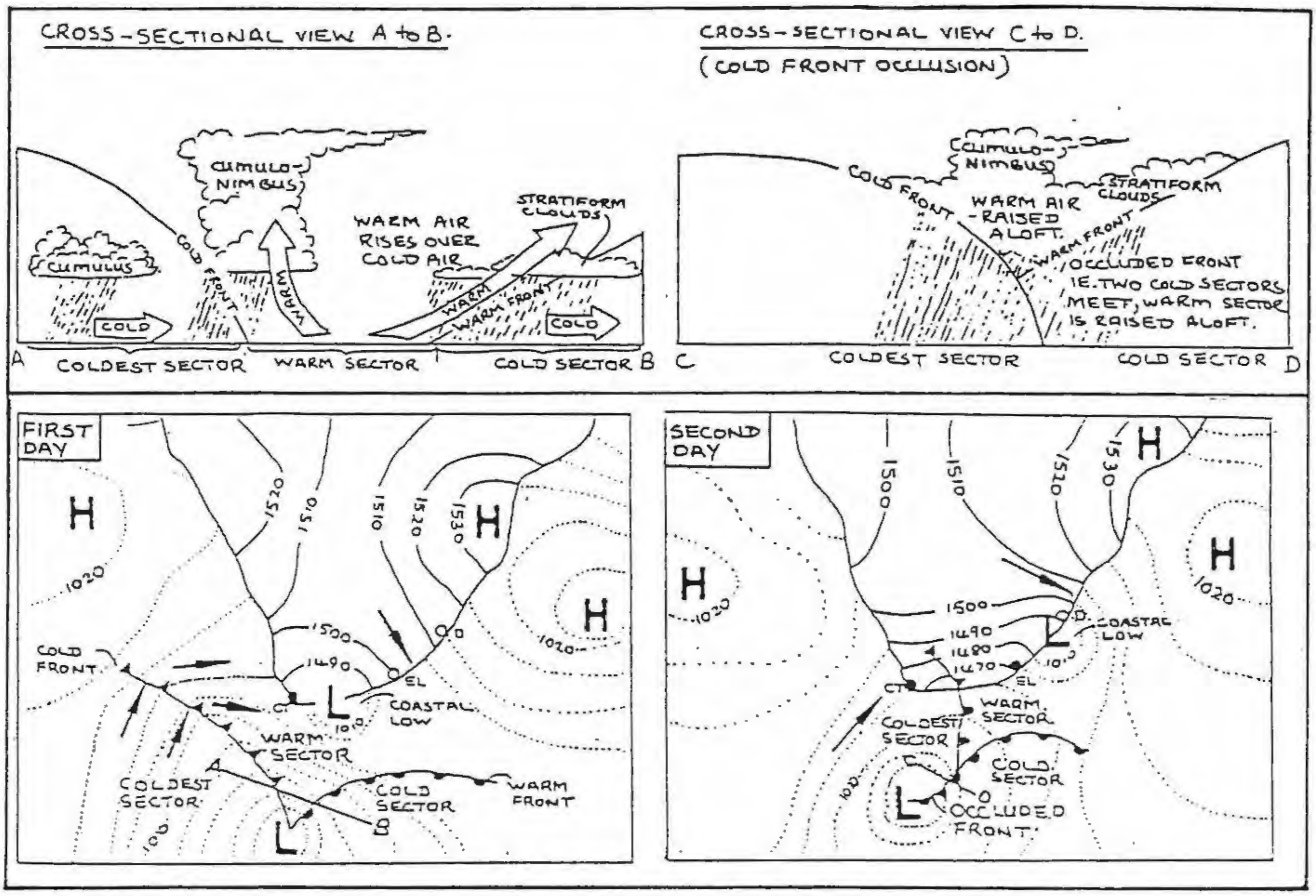
FIGURE 4.3 Unit 3: Cyclonic circulation: Heat lows



KEY FACTS

1. Coastal lows are shallow low pressure cells that originate along the west coast, migrate around the Cape and move northwards towards Natal.
2. They can only exist along coastlines where a steep escarpment is found close to the sea.
3. They are associated with berg winds along their leading edge and with fog (west coast) and cooler, cloudier conditions along their back edge.
4. They herald the approach of a cold front.

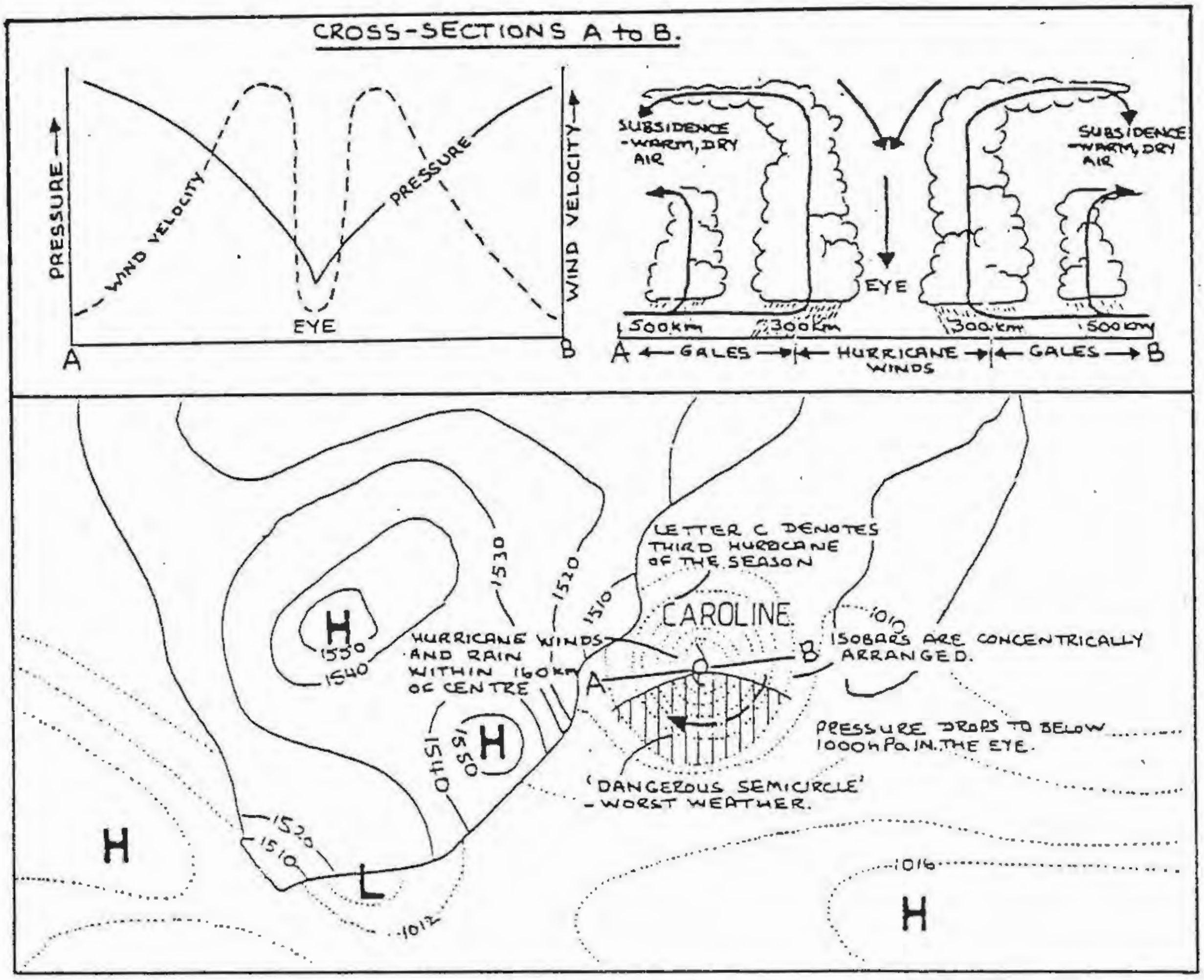
FIGURE 4.4 Unit 4: Cyclonic circulation: Coastal lows



KEY FACTS

1. Frontal depressions are also known as mid-latitude or temperate depressions.
2. They move from west to east and affect southern African weather in winter especially.
3. Frontal depressions are made up of low pressure troughs and cold and warm fronts.
4. The cold front is found in front of the cold air mass or sector; the warm front is found in front of the warm air mass.
5. The warm air sector contains tropical air, while the cold sector contains polar air.
6. The air temperature within the cold sector varies. In the diagrams above the coldest air is found directly behind the cold front, but it may occur that the coldest air is located immediately in front of the warm front.
7. The coastal low precedes the passage of the cold front resulting in off-shore berg wind conditions ahead of the coastal low (see arrow near East London on the map), followed by cool cloudy weather behind the coastal low and then a cold snap a few hours later as the front passes.
8. Eventually the two fronts meet and an occlusion occurs.
9. Winds back (shift anticlockwise in direction) with the passage of the cold front - in the diagram above they back from westerly to south-westerly (see arrows west of Cape Town in the two maps).

FIGURE 4.5 Unit 5: Cyclonic circulation: Frontal depressions



KEY FACTS

1. Tropical depressions are also called hurricanes, tropical cyclones or typhoons.
2. They are found over warm tropical oceans mainly in summer.
3. They move over the Mocambique channel from the east and then curve south-east between 20°S and 30°S of latitude.
4. They do not generally enter Natal or Transvaal.
5. The symbol for a tropical depression is ϱ.
6. They are smaller than frontal depressions and they are not associated with cold or warm fronts.
7. Winds blow parallel to the isobars in a clockwise direction.
8. The centre of the tropical depression is called the eye - here conditions are warm, fairly calm and clear and the air pressure is at its lowest (900 - 1000 hPa).
9. Surface winds on one side of the tropical depression blow in the opposite direction to those on the other side - at A winds blow from the SE while at B they blow from the NW.
10. The leading quadrant has the worst weather - very heavy rain and devastating winds which generate huge waves at the coast.
11. The tropical depression dies out over land because of friction and an absence of warm water from which it derives its energy.

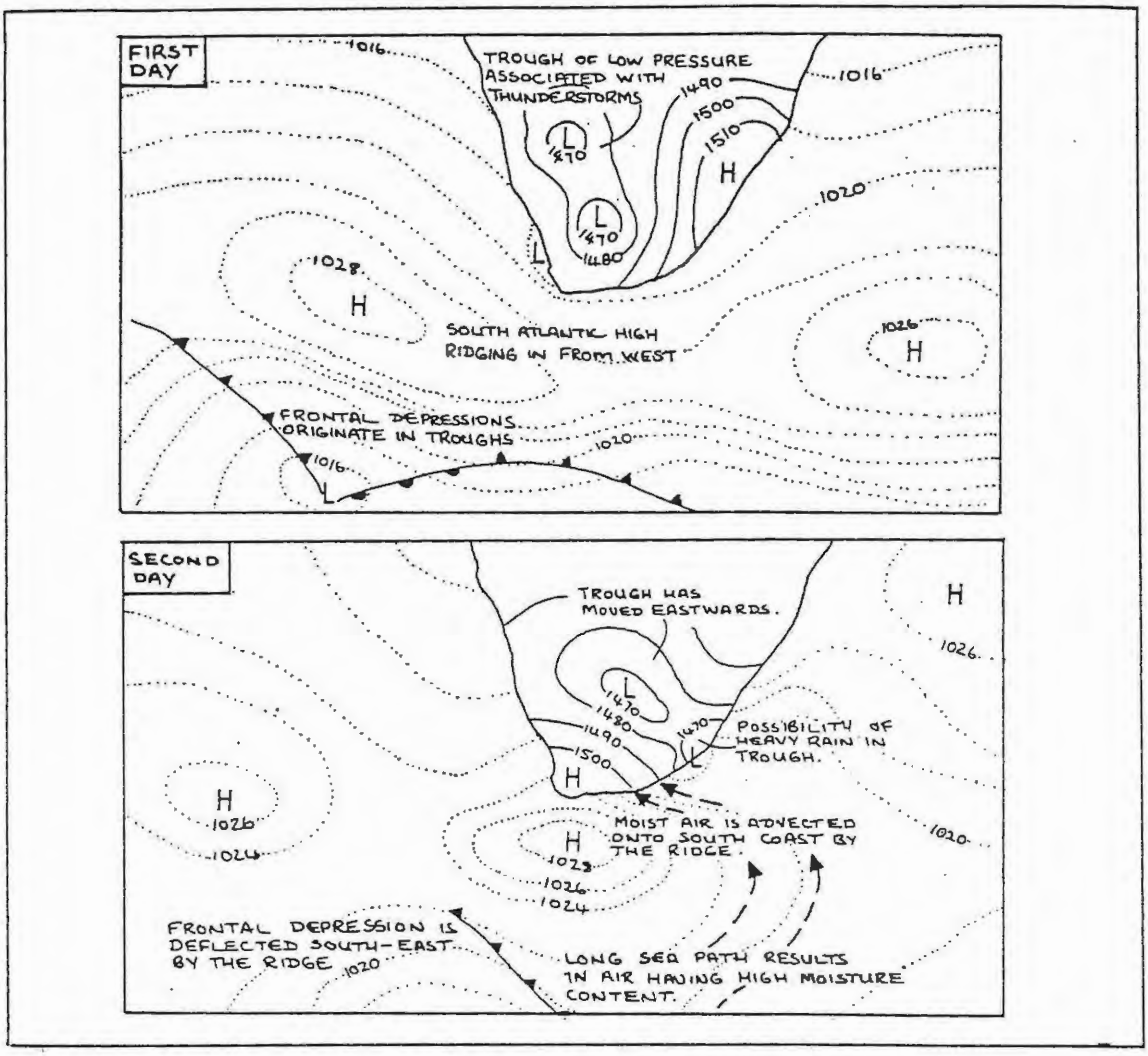
FIGURE 4.6 Unit 6: Cyclonic circulation: Tropical depressions

The unit on ridges and troughs (Figure 4.7) brings together material from the anticyclonic and cyclonic types. Side views are possible but not necessary if repetition is to be avoided. A two-day sequence was used to convey the eastward ridging process and its associated advection of moist air over the east coast.

Composite types

The last three units (Figures 4.8, 4.9 and 4.10) focus on composite patterns rather than on the easily-classified single-type examples. This approximates more closely with real world patterns in which a number of circulation types usually occur together to create complex composite patterns. A concise summary of the syllabus content on winter and summer circulation patterns is also achieved.

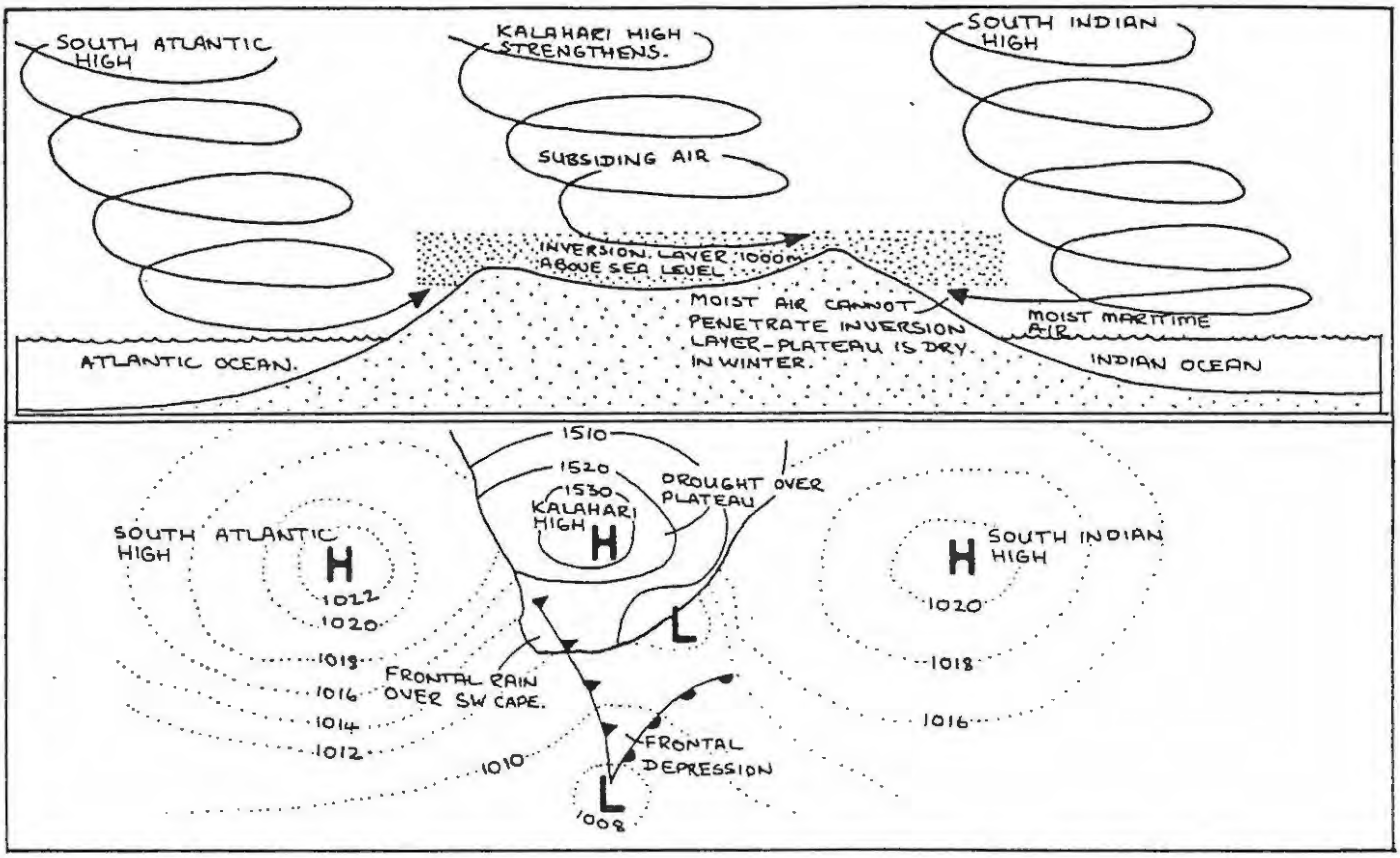
Built into this sequence of weather types are climatological components such as the various cyclonic features (eg. frontal depressions, coastal lows, etc.), anticyclonic circulation (eg, the Kalahari high which is often misunderstood by pupils), the interaction between pressure systems, and typical seasonal scenarios such as summer and winter patterns. An effort is made to include aspects from formative years in each weather type. In the unit on line thunderstorms, for example, Taljaard's model encountered in standard 8, and the standard 10 section on line thunderstorms are integrated.



KEY FACTS

1. A ridge is an elongated extension of an anticyclone which invades an area of lower pressure. This invasion or ridging in generally occurs in a west-east direction.
2. A trough is an elongated low pressure system normally orientated in a north-south direction between two ridges of higher pressure.
3. Ridges and troughs generally migrate from west to east.
4. Ridges are particularly noticeable south of the sub-continent when the South Atlantic high forms a ridge which eventually moves towards the Indian Ocean.
5. As the South Atlantic high ridges in south of the sub-continent, moist air is advected onto the south and east coasts.
6. Troughs are associated with frontal depressions and with line thunderstorms over the plateau in summer.

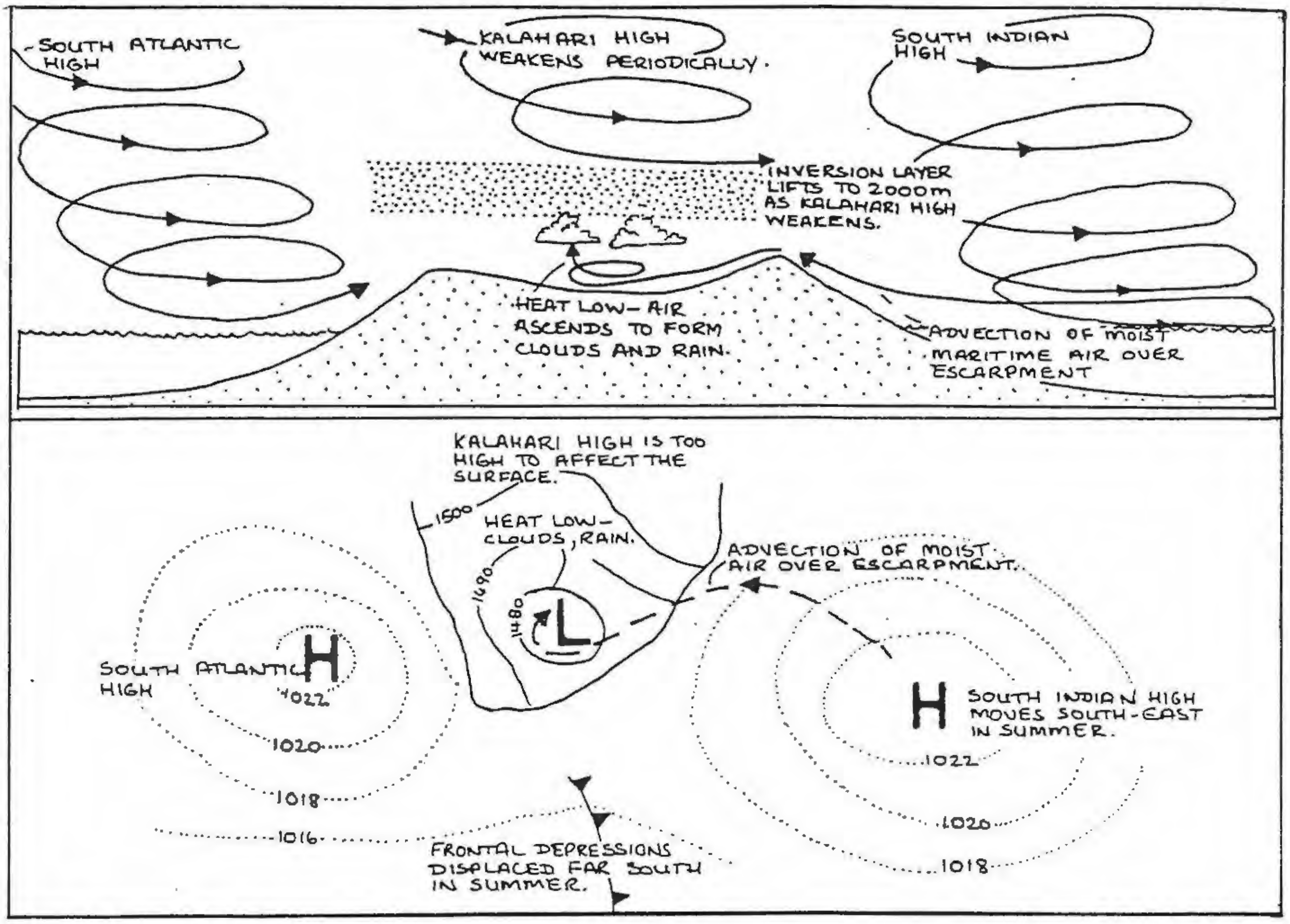
FIGURE 4.7 Unit 7: Ridges and troughs



KEY FACTS

1. Anticyclonic circulation dominates southern African weather in winter.
2. The South Atlantic high, the Kalahari high and the South Indian high intensify and form a continuous belt of high pressure over the sub-continent.
3. The Kalahari high exerts its influence down to approximately 1000 metres above sea level (ie below plateau level).
4. The subsiding air of the anticyclone heats up adiabatically creating an inversion layer in which temperature increases with height so that air cannot rise (ie stable air) and drought prevails.
5. The inversion layer acts as a barrier and prevents moist maritime air from crossing the escarpment.
6. Deep clouds cannot form over the plateau because of the subsiding air of the Kalahari high and because of the absence of moist maritime air.
7. A marked diurnal temperature range exists - days are normally clear and mild, while nights are cold and frosty because of the absence of cloud cover which allows terrestrial radiation.
8. The SW Cape and the southern coastal areas are periodically invaded by frontal depressions resulting in rain and occasional snow over high-lying areas.
9. Berg winds are most frequent in winter (April to September). They occur along the coast with the approach of a cold front (see notes on COASTAL LOWS and FRONTAL DEPRESSIONS).

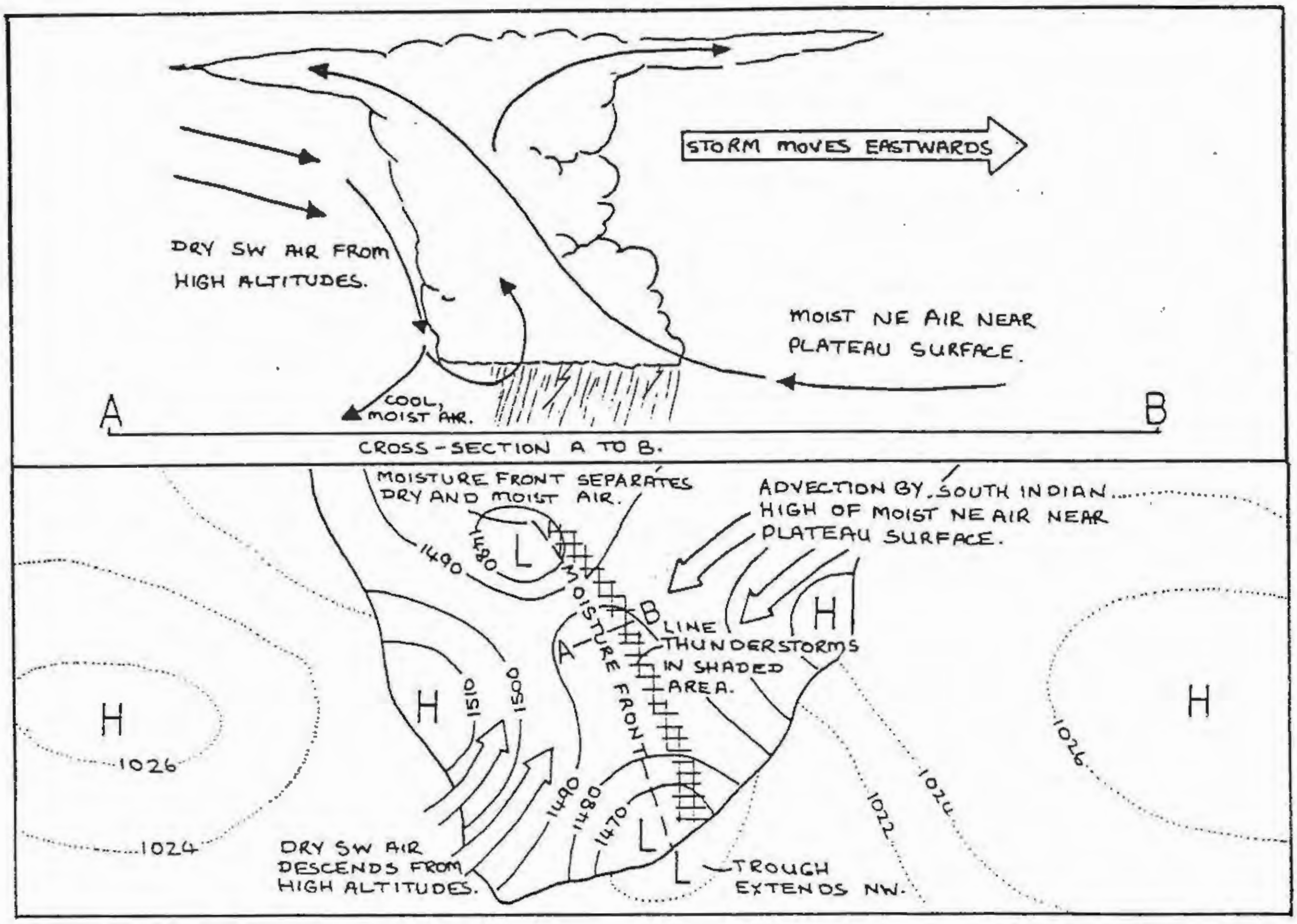
FIGURE 4.8 Unit 8: Winter circulation



KEY FACTS

1. The South Indian high and the Kalahari high move southwards in summer so that frontal depressions are frequently kept too far south of the Cape coast to affect southern African weather.
2. The anticyclonic circulation over the sub-continent is periodically disturbed in summer.
3. The Kalahari high weakens on some days and the inversion layer lifts to over 2000 metres above sea-level and is situated well above the escarpment.
4. A shallow heat low then develops over the plateau and draws in moist South Indian air which is advected over the escarpment by the South Indian high.
5. If the heat low is deep, the moist maritime air ascends, forms deep cloud and rain results.
6. The lifting of the inversion layer is temporary. As the Kalahari high strengthens, the heat low disappears and fine weather conditions return.
7. Where the South Atlantic high and the South Indian high meet, line thunderstorms occur along the moisture front (see notes on LINE THUNDERSTORMS).

FIGURE 4.9 Unit 9: Summer circulation



KEY FACTS

1. Line thunderstorms are a summer feature when the inversion layer lifts and allows moist Indian Ocean air to penetrate the interior.
2. These thunderstorms occur along a line orientated in a NW-SE direction along the eastern side of a trough lying over the interior.
3. The trough of low pressure is located between the South Atlantic high and the South Indian high.
4. The contact zone between the South Atlantic high and the South Indian high is also known as the moisture front with drier air to the south-west of it and moister air to the north-east.
5. Cool and dry south-westerly air from the South Atlantic high ridges in under moister and more unstable north-easterly air from the South Indian high. This unstable air rises, cools and condenses into cumulonimbus clouds along the eastern side of the trough and results in thunderstorm activity.
6. The formation of the thunderstorms is reinforced by solar heating during the day and they reach their maximum development in the late afternoon and early evening.
7. The storm line migrates across the sub-continent in an easterly direction.
8. Because line thunderstorms develop where two different air masses meet, they are also called frontal thunderstorms.

FIGURE 4.10 Unit 10: Line thunderstorms

4.5 THE VALUE OF THE WEATHER TYPE MODELS

The weather type models are taught in the context of synoptic chart interpretation as the synoptic chart provides an ideal vehicle for integrating and consolidating the S.A. climatology components of the senior secondary syllabus (Van Jaarsveld, 1988). The greatest value of such a systematic series of units lies in its ability to offer generalisations, to blend South African climatology and synoptic chart work using diagrams to aid the understanding of abstract concepts and their inter-relationships.

Boardman (1983) and Burton (1986) discuss the problem of micro-thinking, ie attention to too much detail, in the context of topographical map reading. The synoptic chart does not contain the variety of symbols used in the topographical map, but it is also a highly sophisticated map because its symbols are loaded with abstract concepts. The synoptic charts used in text books are often direct copies of those produced by the weather bureau. Coupled with the clutter of sometimes illegible symbols, the vast amount of information represented in the chart makes it difficult for the pupil to perceive the overall picture. Because it is a model, the weather type model eliminates the inessentials in which weaker pupils lose themselves in an attempt to present the pupil with the macro-picture.

The weather type models are designed to facilitate the building of mental images rooted in clear three-dimensional perception and gradual conceptualisation of the weather-types was always borne in mind. To aid the pupil's visual perception of the weather-types, schematic diagrams showing cross sectional or depth views are used. Concise annotated notes of only the essentials associated with each weather-type are incorporated in the diagram so as to avoid unnecessary visual noise.

As the pupil progresses through the weather type models, concepts from earlier units are again encountered and revised, possibly in more depth. Subsequent units subsume earlier units and are expanded into more complex composite weather-types. In other words, both a conceptual deepening and broadening occurs.

4.6 SUPPLEMENTARY AIDS USED WITH THE THEORETICAL WEATHER TYPE MODELS

The use of the weather-types should not always be a substitute for first hand experience of weather or the use of other visual aids. Where possible the pupil's attention must first be focused upon reality, eg. the approach of a cold front with its characteristic 3-phase pattern of warm-dry conditions, cool-cloudy conditions, and cold snap can be clearly observed in Cape coastal areas and may be used as a starting point in developing a model. The everchanging weather patterns can be demonstrated by the use of video material based on television weather reports and sequences of weather charts taken from the local newspaper. Sample or case studies based on a well known weather event (eg. recent flooding in East London, or the effects of hurricane Domoina on the Natal Coast) help to root particular weather-types in reality.

Other models developed and used by the writer in the second phase of the research include:

(i) A polystyrene relief map and cardboard cylinders representing pressure systems.

(ii) Cardboard box and polystyrene models of a frontal depression and occlusion.

(iii) Overhead projector transparencies illustrating the passage of a coastal low and the backing wind concept.

The model in Figure 4.11 was developed to illustrate the relationship existing between the Kalahari high and the coastal low. The greatest value of the model is that the pressure components (cylinders) can be moved around the relief map to show their locations and migration over time and are therefore useful in developing the pupil's ability to predict weather patterns associated with the passage of the coastal low. A further advantage is that the model allows for manipulation by both teacher and pupil. Limitations are that pupils may perceive the cells as perfectly cylindrical and isobaric values and surfaces cannot be shown.

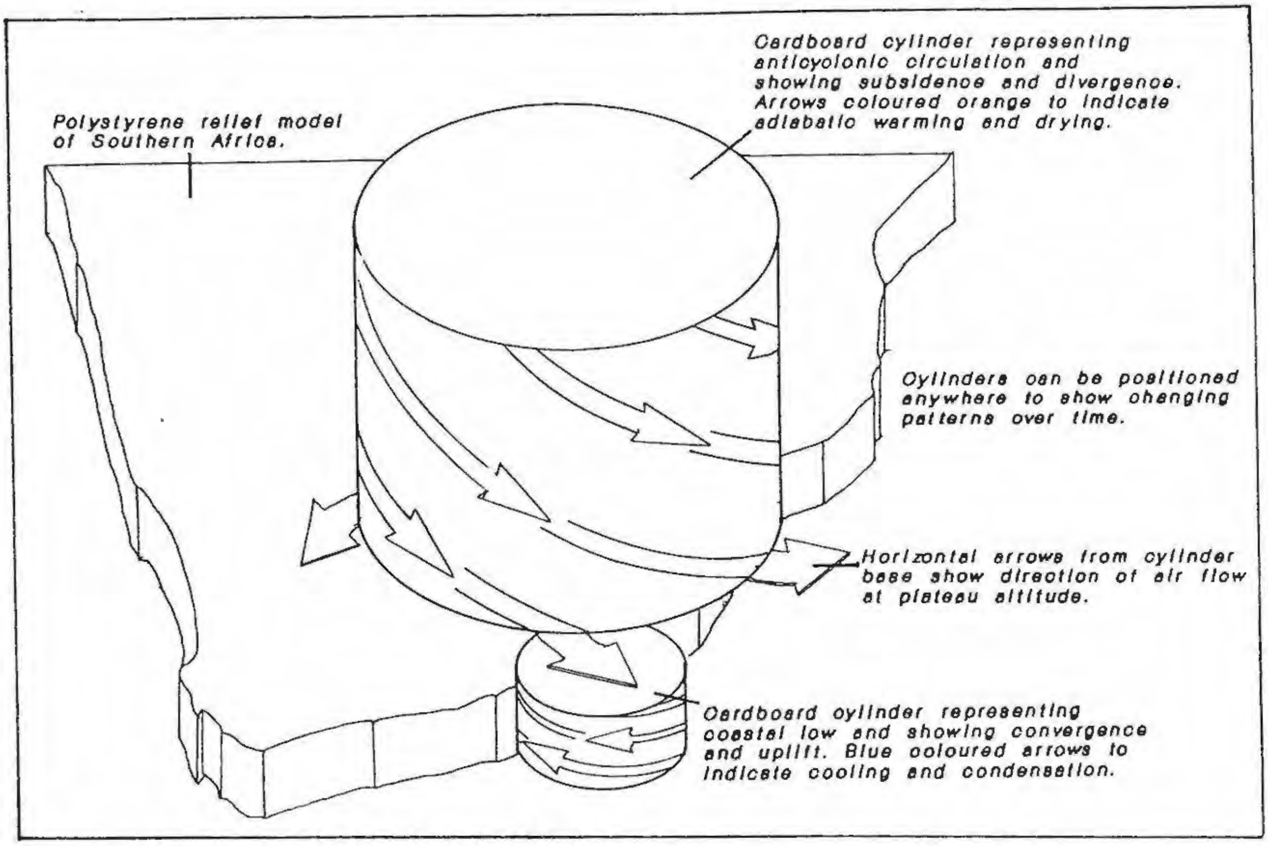


FIGURE 4.11 Model used to teach coastal lows

The frontal depression is a highly complex weather phenomenon and is extremely difficult to visualise in three dimensions. The writer sought a manner to illustrate the depression using materials that are easily and cheaply available to the teacher. A cardboard box, overhead projector transparencies and powder paints were used to construct the model in Figure 4.12. The model suffers the disadvantages of not being true to scale and of separating too sharply the air masses involved; nevertheless, it does make tangible the invisible elements of the frontal depression in a way that cannot

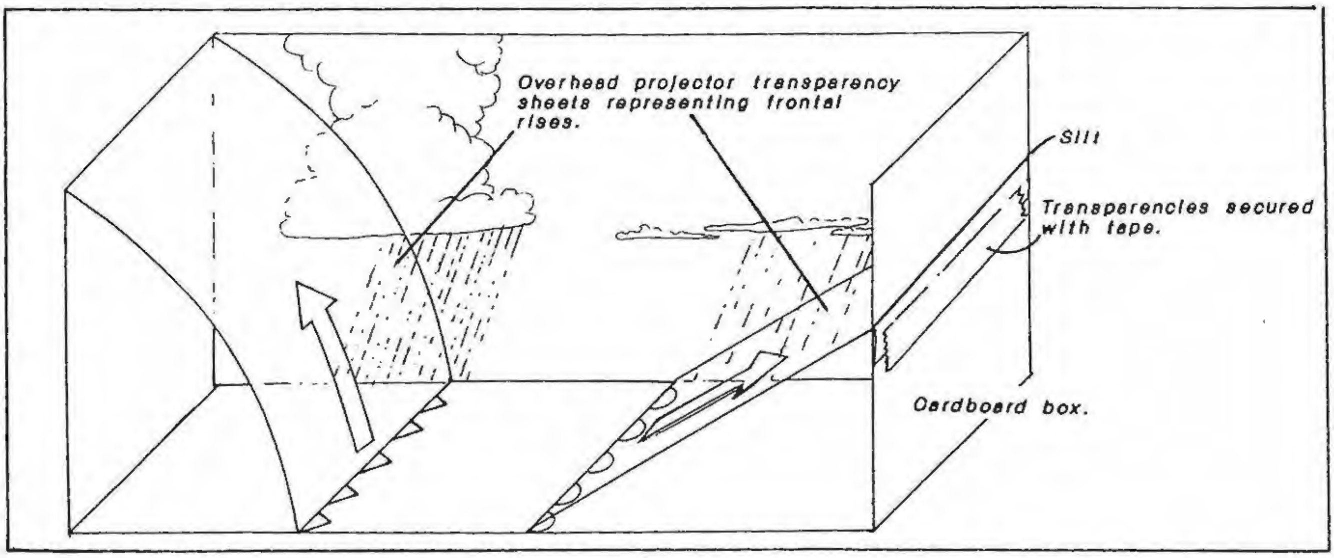


FIGURE 4.12 Cardboard box model of a frontal depression

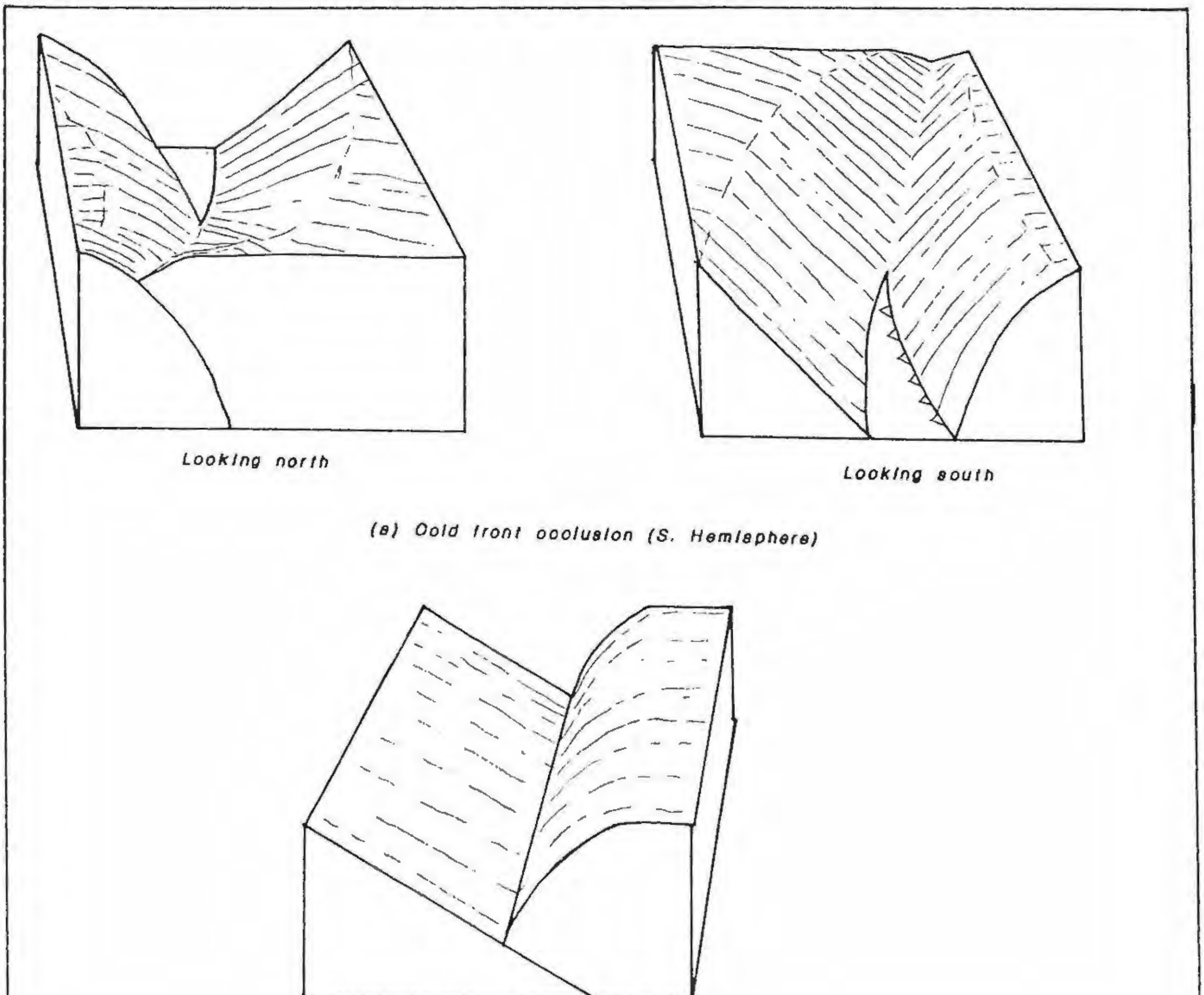


FIGURE 4.13 Polystyrene models of frontal occlusions

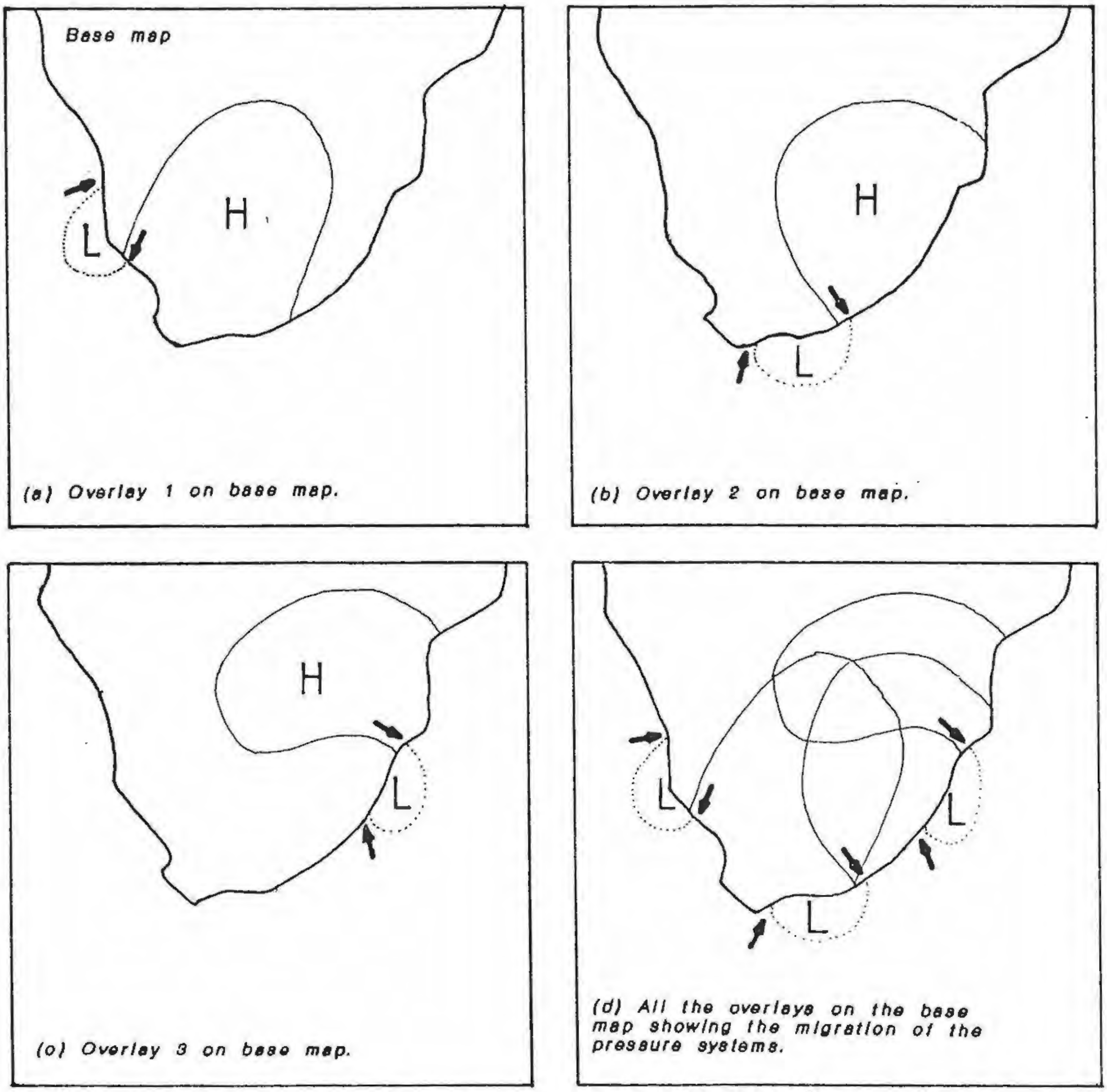


FIGURE 4.14 Overhead projector transparency overlays illustrating coastal low migration

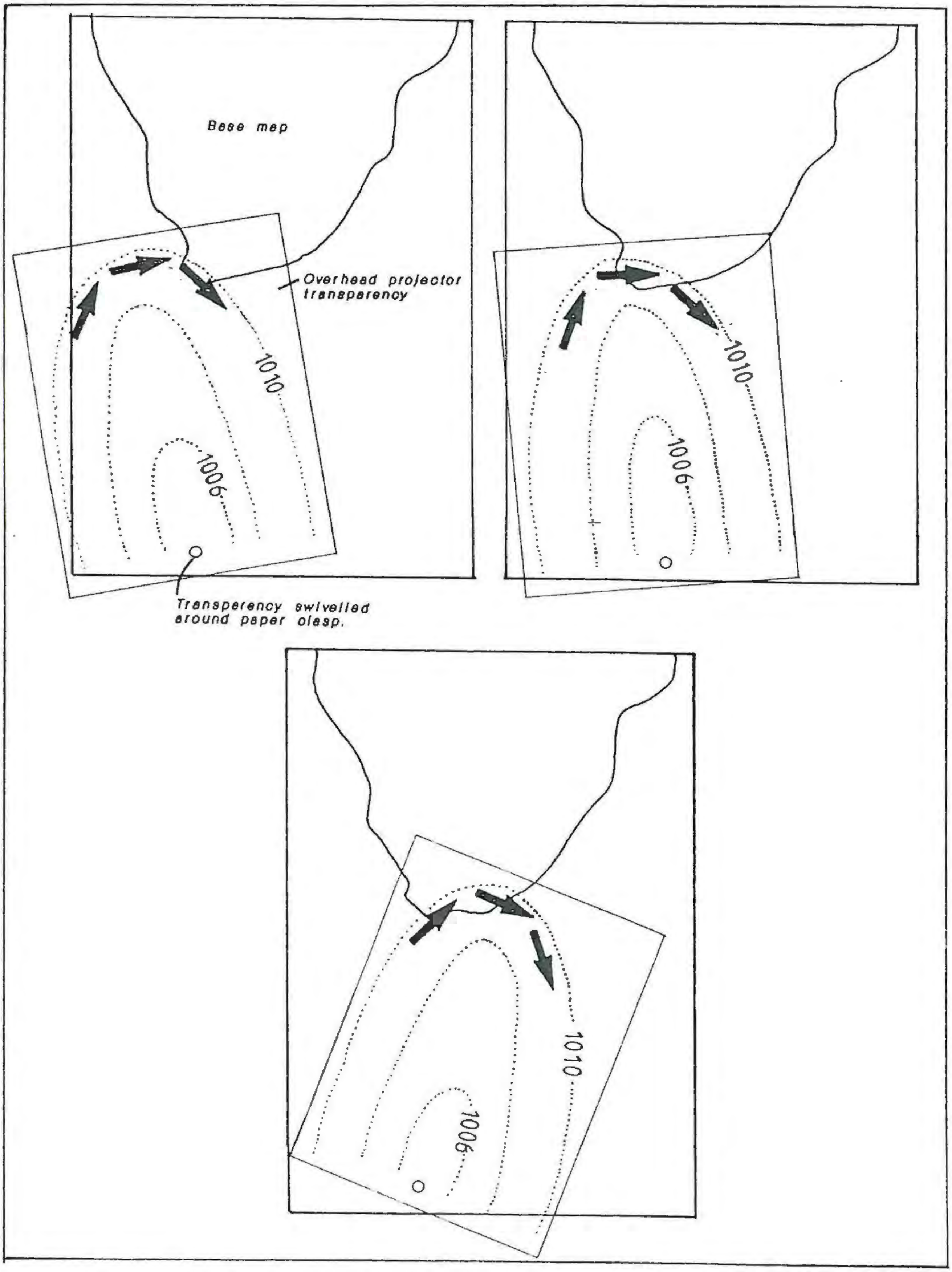


FIGURE 4.15 Overhead projector transparency models showing the changes in wind direction and pressure associated with passage of a frontal depression

adequately be achieved diagrammatically. The same can said for the polystyrene models in Figure 4.13.

The overhead projector transparency models (Figures 4.14 and 4.15) provide a means of displaying movement of systems over time thus coping with the problem of temporality discussed in chapter 2. The drawings were done on the back of the transparencies so that scribbling during the course of the lesson could be erased without removing the drawings.

4.7 SUMMARY

Both theoretical and hard models were used in the second phase of the classroom research. The theoretical weather type models involved the use of side views, plan views and notes expressing key facts. In this way each weather type progresses through degrees of abstraction from iconic (side view) to symbolic (synoptic charts and notes) representations. A conceptual progression from simple to complex composite weather types was achieved. Supplementary models used as supporting aids were also presented.

CHAPTER 5

RESULTS OF THE SECOND PHASE OF THE RESEARCH: THE TWO CLASSROOM SETTINGS

The results of this stage of the research embrace the two settings in which the models were tested:

1. The standard 10 setting involving quantitative research into the effectiveness of the weather type model as a learning device;
2. The standard 9 setting which consisted of:

2.1 The teaching and evaluation of the lesson on the coastal low.

2.2 The teaching and evaluation of the lesson on the mid-latitude depression.

2.3 The tests on coastal lows and mid-latitude depressions.

2.4 The evaluation of the course as a whole using a semantic differential and teacher observation summary.

Exemplars of the test papers, questionnaires and observation schedules used as research instruments to gather the data upon which these results are based, appear in Chapter 3 which deals with the methodology of the research.

5.1 THE STANDARD 10 EXPERIMENT

The problem the researcher wished to investigate at this point can be stated as:

Will standard 10 pupils assimilate climatological facts and concepts from a certain section of the geography syllabus better if theoretical weather type models were incorporated in the text?

The null hypothesis could be expressed as follows:

There is no significant difference between the number of facts and concepts which standard 10 pupils remember about the climatology section of the syllabus when they use a theoretical weather type model and when they do not.

The action procedures as set out in chapter 3 were followed. The data used in the t-test appear in Table 5.1 below.

The calculated t-value (0,7975) in a two tailed test is smaller than the table value (2,228) at the 5% level of significance; therefore, the null hypothesis cannot be rejected, for there is no significant difference between the arithmetic means of the two sets of scores. It would appear, therefore, that the theoretical weather type model, used in the test by Group A, made no significant difference to the pupils' assimilation of facts and concepts.

It must be emphasised that no other teaching occurred and that only the theoretical weather type model was used without support from the other models. The assumption was that because other types of model, such as hard models and iconic models were used in previous years, standard 10 pupils are able to use theoretical models.

TABLE 5.1 Calculation of t-value for marks attained in the standard 10 test on winter circulation over southern Africa.

t TEST FOR TWO SETS OF MATCHED PUPILS

Students Pair	Achievement Group A	Group B	D=A-B	D^2
1	13	13	0	0
2	15	6	9	81
3	13	6	7	49
4	14	6	8	64
5	9	8	1	1
6	12	9	3	9
7	5	7	-2	4
8	8	7	-1	1
9	9	15	-6	36
10	5	12	-7	49
11	6	4	2	4
11 (N)			14 (ΣD)	298 (ΣD^2)

$$t = \frac{\sqrt{N-1}\,\Sigma D}{\sqrt{N\Sigma D^2 - (\Sigma D)^2}} \qquad dF = N - 1$$

$$t = \frac{\sqrt{10} \times 14}{\sqrt{11 \times 298 - 14^2}}$$

$$= \frac{44,2719}{55,5158}$$

$$= 0,7975 \quad (dF = 10)$$

<u>Comments on the results</u>

The following reasons may explain the results:

(i) The pupils cannot use the weather type models as a learning device without first being <u>taught</u> to use them. The pupils had no previous experience of the theoretical weather type models in a didactic situation. This concurs with

Bailey's (1974: 36) notion that three-dimensional diagrams do not always convey an impression of depth to those who are not used to the convention. He advises that three-dimensional drawings ought to be supplemented by the use of hard models.

(ii) Skills that are learnt are not automatically retained, they must be practiced constantly if they are to be developed (Boardman, 1986).

(iii) Using IQ scores to match or pair the pupils has its limitations (as identified in chapter 3). These limitations are borne out by the test results. This aspect is highlighted by the fact that two of the pupils' results in group B (pairs 9 and 10 in Table 3.8) are anomalous as they attained marks well above pupils of similar ability, suggesting that their IQ scores may need reassessing. If the marks for pairs 9 and 10 are omitted from the t-test, then the t-value for that test is calculated as 2,3501 (dF=8), which is greater than the table value on the 5% level (2,306) but less than the table value on the 1% level (3,355). The null hypothesis could then be rejected with 95% certainty and there would therefore be a significant difference in the arithmetic means of the two groups. It could then be concluded that the use of the weather type model did result in more facts and concepts being remembered.

The researcher had expected to detect a difference in the quality of answers given by the two groups. Since the experimental group (Group A) was provided with a depth perspective diagram, it was expected that its answers would reveal a greater use and understanding of concepts rather than facts. However, it was realised after the research activity that all that was tested was each group's ability to recall the learning material. Conceptual understanding could have been measured only if the facts and concepts had been applied to a different synoptic situation in the test.

5.2 THE STANDARD 9 RESEARCH SETTING

The author, as participant observer, taught two lessons on weather types based on the weather type models in chapter 4, viz. coastal lows and mid-latitude depressions. A variety of other models, such as polystyrene representations of a frontal depression and meteosat photographs, were also used.

An attempt was made to progress from the real world to an iconic representation and then to a symbolic representation of the coastal low and mid-latitude depression.

The teacher of the class and head of the school's geography department observed the lessons as non-participant observer and was guided in his observation by using an observation schedule (Table 3.2). At the end of the two lessons, his feelings on the lessons and the model-based strategies used were reflected in an observation summary (Table 3.3).

At the end of each lesson the pupils completed a test (Tables 3.4 and 3.5) to provide an indication of the extent to which the lesson material was understood.

The pupils finally completed a two part evaluation of the lesson by rating their feelings and also providing other information not covered by the ratings (Table 3.7). The researcher used this technique instead of structured interviews for two reasons:

(i) A formal structured interview is time consuming. All standard nine pupils at the school were due to write tests on a fairly wide area of the climatology syllabus. To have asked the teacher for two extra periods to conduct the interviews on the two lessons would have been an imposition on his teaching schedule and would have disadvantaged the pupils in the test.

(ii) This technique is well suited to gauging the feelings of an entire class in a semi-structured manner, which is neither as time consuming nor as rigid as a formal structured interview.

The nine pupils who were present for the whole course finally completed a semantic differential at the end of the course to rate their feelings in respect of their experience of, their involvement in and the meaning they attributed to the course.

5.2.1 The teaching and evaluation of the lesson on the coastal low.

Lesson procedure

The lesson was introduced by focusing the pupils' attention on a table showing typical changes in atmospheric pressure, temperature and humidity over a five day period in winter in the Eastern Cape (Figure 5.1 below). They were asked to discover patterns and relationships in the data and to draw rough graphs to show them. The data reflected the passage of a coastal low and cold front.

A polystyrene model of the relief of southern Africa, and paper cylinders representing high and low pressure cells were then used to illustrate the important characteristics of southern hemisphere cyclonic and anticyclonic circulation in three dimensions (Figure 4.11). Concepts such as convergence, rising, subsidence, divergence, and anticlockwise and clockwise spiralling were explained. By placing the cylinders at various positions relative to the relief model of southern Africa, the migration of the pressure systems was simulated. Questions were asked by the researcher to determine the depth of their understanding of these important concepts.

The schematic diagrams from the coastal low theoretical weather type model in chapter 4 were used to give the pupils a cross sectional and depth perspective of the coastal low

WEATHER CHANGES OVER A 7 DAY PERIOD IN WINTER

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Pressure (hPa)	1024	1022	1018	1016	1016	1014	1012
Temperature (°c)	26	28	27	20	20	16	15
Humidity (%)	41	28	20	82	74	93	45
Wind direction	NE	ENE	ENE	W	SW	SSW	SSW

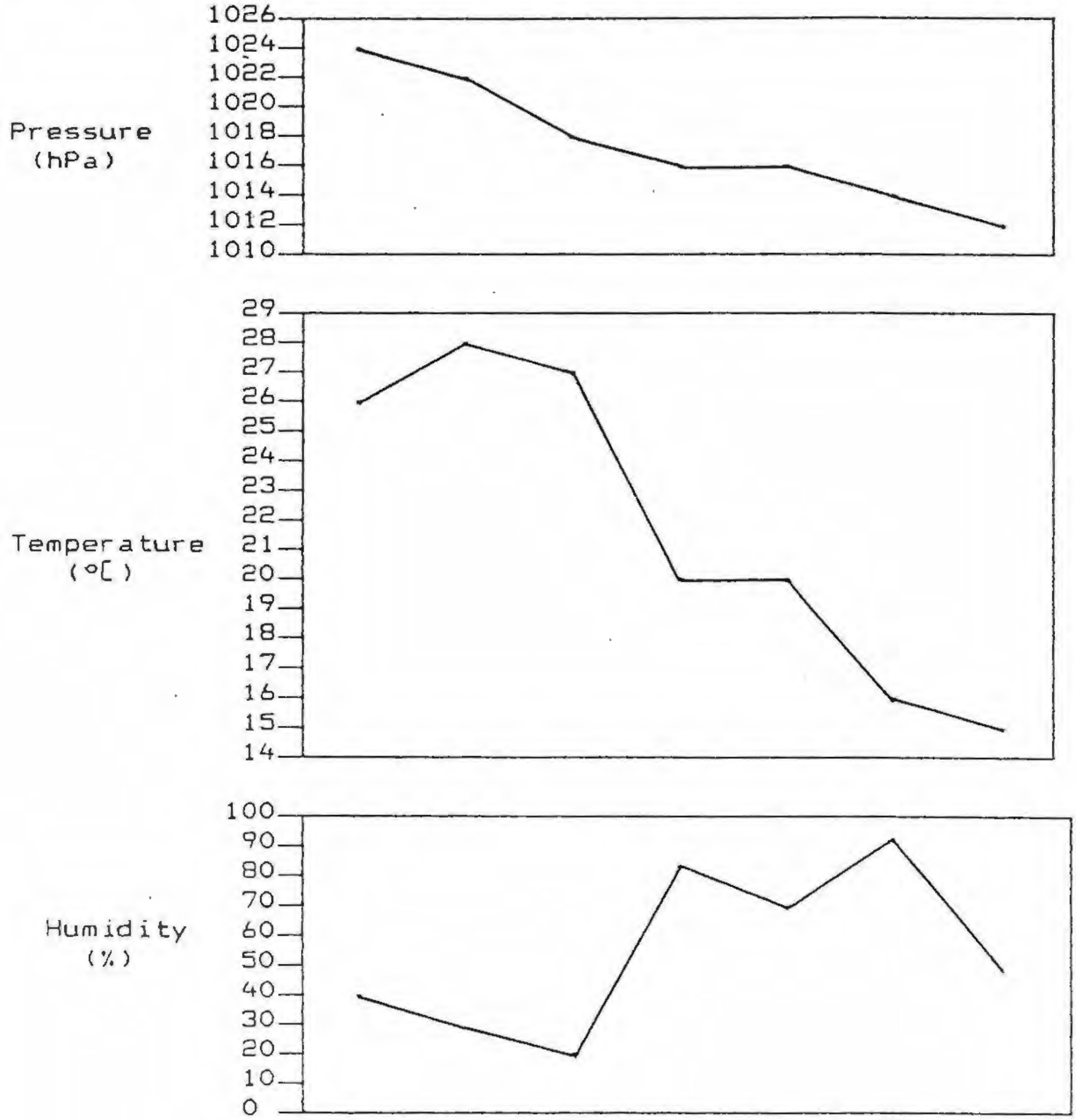


FIGURE 5.1 Introductory exercise for the lesson on coastal lows with the standard 9 class

phenomenon. The lesson was consolidated by showing the changing isobaric patterns on a synoptic chart using the overhead projector. Overlays illustrating the isobaric patterns and wind directions associated with the coastal low were superimposed over an outline map of Southern Africa (Figure 4.14). Three isobaric configurations were shown individually and sequentially with the coastal low positioned along the west, south and east coasts. All three overlays were then shown simultaneously to illustrate the migration of the pressure systems over time.

A test (Table 3.4) comprising short sentences and paragraphs was written after the pupils were given an opportunity to examine the theoretical weather type model on coastal lows. It was hoped that the model would crystalise all pertinent information on the coastal low through the use of a synoptic chart, a schematic diagram and key notes. The pupils were given five minutes to study the weather type model and ten minutes to write the test without referring to the model.

Results of the pupil evaluation

The summary in Table 5.2 indicates the pupils' evaluation of the various items on the evaluation form. This data is depicted as percentages in graphic form in Figure 5.2 below.

TABLE 5.2 Numbers of pupils choosing each rating for the lesson on coastal lows

NUMBER OF PUPILS PRESENT = 10
NUMBER OF PUPILS ABSENT = 2

RATINGS USED
1 = not at all
2 = partially
3 = fully

QUESTIONS ASKED	1	2	3
To what extent :			
1. did the models aid your understanding of coastal lows?	0	3	7
2. did the cross-sectional diagrams aid your understanding of coastal lows ?	0	4	6
3. did you understand the notes (key facts) ?	0	0	10
4. do you feel confident about interpreting coastal low information from a synoptic chart ?	0	6	4
5. have you grasped the following concepts:			
low pressure cells ?	0	3	7
high pressure cells ?	0	3	7
offshore flow ?	1	3	6
onshore flow ?	0	4	6
berg wind ?	1	3	6
advection ?	1	5	4
To what extent:			
6. did you understand the lesson as a whole ?	0	4	6
7. did the lesson interest you ?	0	5	5
8. did you enjoy the lesson ?	0	4	6
9. did you find the lesson clear ?	0	3	7
TOTALS	3	50	87

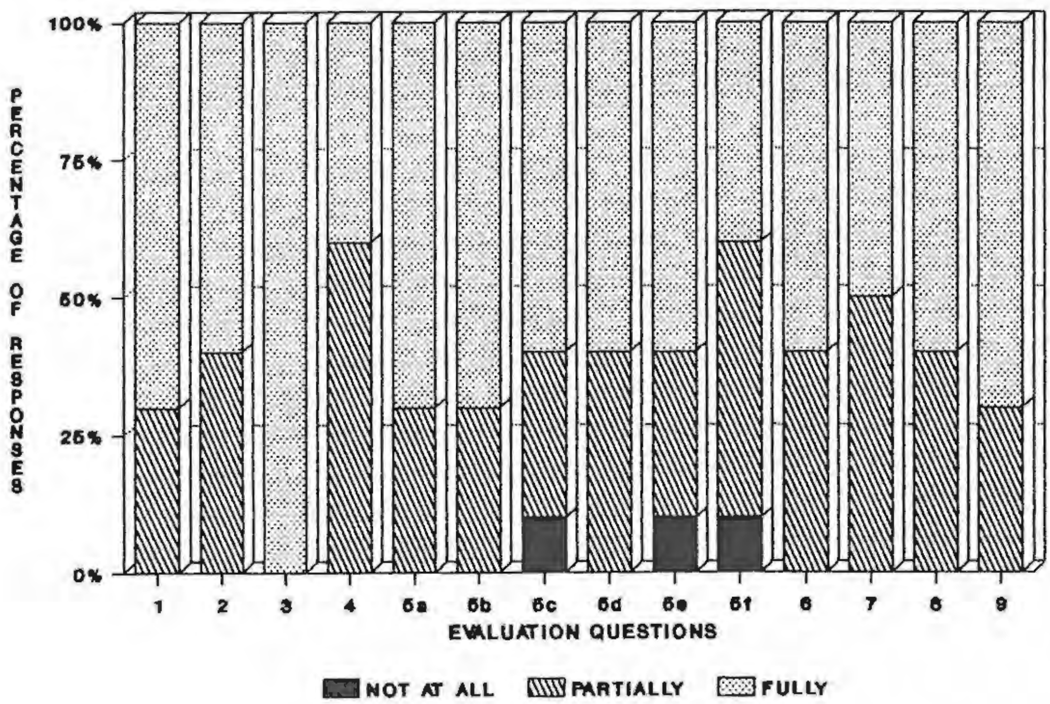


FIGURE 5.2 Percentage of responses choosing the various ratings for the lesson on coastal lows

Evaluation

It appears from the data that three concepts, viz. offshore flow, berg wind and advection posed difficulties for three pupils only. These negative responses comprise only 2,14% of the total responses.

All the pupils indicated that the key facts at the end of the weather type unit were fully understood. Over half of the pupils found that:

(i) the models and diagrams fully aided their understanding;

(ii) except for advection, all the other concepts were grasped fully;

(iii) the lesson as a whole was fully understood and enjoyed, and was found to be clear and interesting.

(iv) they felt partially confident about interpreting a similar synoptic chart.

The opinions expressed by the pupils in the second part of the evaluation (Questions 1.1 to 2) may be summarised as follows:

Qu. 1.1 The parts of the lesson that they found most interesting were the use of diagrams and models, the relevance of the lesson to southern Africa, the weather characteristics of the coastal low, and the formation of pressure cells.

Qu. 1.2 The majority (7 pupils) could not find anything boring about the lesson. Two pupils listed the development and movement of the coastal low as most boring, while one mentioned the statistical work in the introduction.

Qu. 1.3 Those areas that were easiest to understand included weather changes with the onset of the coastal low, and, high and low pressure cells and their movements. Two pupils stated that they found everything easy to understand.

Qu. 1.4 Onshore and offshore flow were mentioned as most difficult to understand by two pupils, individual pupils listed adiabatic warming, statistical work and the development of the coastal low in winter as difficult to grasp. Half the pupils had nothing listed.

Qu. 2 Six pupils made no further comment on the lesson, two were pleased with the clear presentation of the lesson and found the models valuable as a learning aid. One pupil suggested ways of making the relief model aesthetically more appealing.

<u>Results of the non-participant teacher's evaluation</u>

The non-participant teacher observation schedule (Table 5.3) reveals the following:

(i) There was a progression in the teaching from the real world to iconic representation to symbolic representation.

(ii) Iconic models were used more than other types while cross sections were used the least.

(iii) At least six concepts were used.

(iv) Most of the questions asked by the teacher were of the recall type, although problem solving questions were also asked throughout the lesson.

(v) Pupils sought clarification of some concepts, but asked no questions involving clarification of the teaching instruments used.

(vi) Pupils responded to most of the questions asked.

TABLE 5.3 Geography teacher observation schedule for the lesson on coastal lows

	Minutes 0–5	5–10	10–15	15–20	20–25	25–30	30–35
<u>SECTION A</u>							
1. Reference made to real world	✓	✓✓✓					
2. Topic definition	✓✓	✓					
3. Use of key concepts	✓	✓✓	✓✓	✓			
4. Use of models during the lesson:							
4.1 iconic (hardware models)	✓	✓✓✓	✓✓✓✓	✓	✓✓		
4.2 cross sections			✓	✓			
4.3 weather types (teaching units)			✓	✓✓	✓		
4.4 synoptic charts				✓✓	✓		
<u>SECTION B</u>							
1. Teacher input:							
1.1 questions leading to:							
recall of facts	✓✓✓	✓✓✓✓✓✓	✓✓✓	✓✓✓	✓		
problem solving	✓✓	✓	✓✓✓	✓			
1.2 requiring pupil participation i.t.o:							
direct observation	✓✓	✓	✓✓	✓			
interpretation	✓	✓	✓✓	✓✓			
application	✓	✓	✓✓	✓✓			
2. Pupil input:							
2.1 information sought i.t.o:							
clarification of concepts	✓	✓		✓✓	✓✓		
clarification of instruments used							
other clarification					✓✓✓		
2.2 questions answered	✓	✓✓✓✓✓	✓✓✓✓	✓✓✓	✓		

The non-participant teacher commented that the iconic models helped in the visualisation of anticyclones and depressions, and he suggested that pupils in lower standards be given project tasks to construct similar models themselves. He also felt that the overhead projector transparency used to show the migration of the coastal low around the sub-continent was valuable.

Comments and discussion

It is interesting to note that iconic and hardware models had to be used throughout the lesson to illustrate various aspects that could not be grasped by using diagrams and synoptic maps alone. This lends support to the belief that it cannot be assumed that all pupils reach the Piagetian stage of formal operational thought in their adolescent years. The hardware model can be manipulated to offer different viewpoints, which is an important requirement for the development of spatial visualisation (Eliot, 1970).

The fact that the use of both the theoretical and hardware models was highly rated indicates, perhaps, that their use was novel and interesting.

5.2.2 The teaching and evaluation of the lesson on the mid-latitude depression.

Lesson procedure

Fortunately, the passage of a coastal low and a cold front over East London, two days before the lesson, served as a useful introduction and helped the author to ground the lesson in reality and to appeal to the pupils' first-hand experiences of the weather characteristics and changes that occurred.

Three-dimensional models (Figures 4.12 and 4.13) were used to illustrate the frontal depression in the mature and occluded phases of its life cycle. The invisible air masses associated with a frontal depression were clearly shown. The facts and concepts used in the lesson were then consolidated by referring to schematic or cross sectional diagrams from the theoretical weather type model on mid-latitude depressions in chapter 4.

Synoptic charts showing the migration of the depression over a two day period were used to teach the symbolic representation of the frontal depression. Difficult concepts such as backing of winds and air pressure changes were explained by moving overhead projector transparencies over a base map of southern Africa on the overhead projector (Figure 4.15).

The pupils were then given the weather type model on frontal depressions from chapter 4 to examine for ten minutes. The sheet featured synoptic charts, schematic diagrams and key facts. Thereafter, they wrote an essay-type test (Table 3.5) in which they were required to make a weather forecast for a

48 hour period. They were not permitted to use the model in the test. The exercise demanded the application of skills, concepts and facts learned during the course. They were given ten minutes to complete the exercise.

Results of the pupil evaluation

The summary in Table 5.4 indicates the pupils' evaluation of the various items on the evaluation form. This data is depicted as percentages in graphic form in Figure 5.3.

It appears from the data that only one concept, viz. troughs, was not understood by two pupils. These negative responses comprise only 2.14% of the total responses and were in fact the only negative ratings made for the entire lesson.
No item on the questionnaire received a 100% response on the positive side of the scale.

Over half the pupils found that:
(i) the models, cross sectional diagrams and the key facts aided their understanding of mid-latitude depressions;
(ii) except for the trough concept, the concepts cold and warm fronts, occlusion and, cold and warm sectors were grasped fully;
(iii) the lesson as a whole was fully understood, enjoyed and found to be clear.
(iv) they were less positive with regard to confidence in interpreting a similar synoptic chart, grasping the backing concept, and interest in the lesson.

TABLE 5.4 Numbers of pupils choosing each rating in the lesson on mid-latitude depressions.

NUMBER OF PUPILS PRESENT = 11
NUMBER OF PUPILS ABSENT = 1

RATINGS USED
1 = not at all
2 = partially
3 = fully

QUESTIONS ASKED	1	2	3
To what extent :			
1. did the models aid your understanding of mid-latitude depressions ?	0	1	10
2. did the cross sectional diagrams aid your understanding of mid-latitude depressions ?	0	4	7
3. did you understand the notes (key facts) ?	0	4	7
4. do you feel confident about interpreting mid-latitude depression information from a synoptic chart ?	0	6	5
5. have you grasped the following concepts:			
trough ?	2	6	3
cold front ?	0	1	10
warm front ?	0	1	10
backing wind ?	0	6	5
occlusion ?	0	3	8
warm and cold sectors	0	2	9
To what extent:			
6. did you understand the lesson as a whole ?	0	2	9
7. did the lesson interest you ?	0	6	5
8. did you enjoy the lesson ?	0	5	6
9. did you find the lesson clear ?	0	3	8
TOTALS	2	50	102

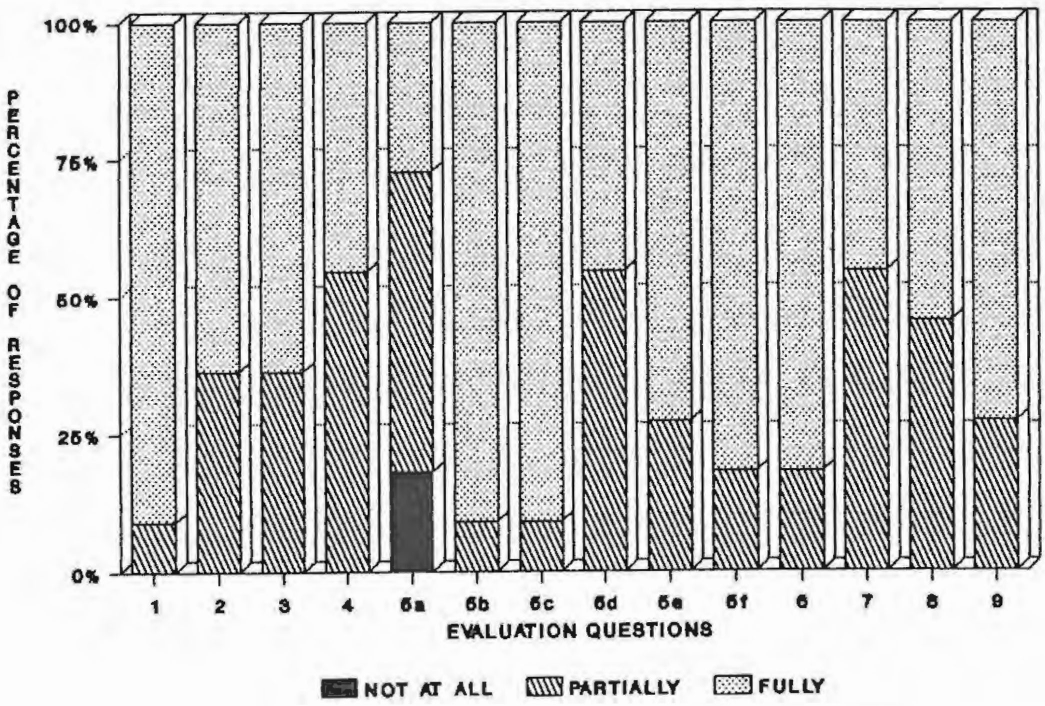


FIGURE 5.3 Percentage of responses choosing the various ratings for the lesson on mid-latitude depressions.

The pupils' opinions in the second part of the evaluation (Questions 1.1 to 2) may be summarised as follows:

Qu. 1.1 The parts of the lesson that they found most interesting were the use of diagrams and models, the relevance of the lesson to southern Africa, the weather characteristics of the mid-latitude depression, and, the occlusion process.

Qu. 1.2 The majority (9 pupils) could not find anything boring about the lesson. One pupil listed the schematic representation of the occlusion as most boring.

Qu. 1.3 Five pupils found the section on frontal conditions and processes easiest to understand, while individual pupils mentioned occlusions, cold and warm sectors, and the cross sectional diagrams. Two pupils indicated that most of the lesson was easy to understand.

Qu.1.4 The backing process was mentioned as most difficult to understand by four pupils, as was the occlusion concept. Two pupils claimed they had difficulty with grasping temperature variations within the cold sector.

Qu. 2 Nine pupils made no further comment on the lesson, two found the lesson clearly presented and easy to understand with the help of the models.

Results of the non-participant teacher's evaluation

The non-participant teacher's observation schedule (Table 5.5 below) indicates the following:

(i) More key concepts (thirteen) were used by the teacher in this lesson than in the former.

(ii) Iconic models were again used more than other types and the weather type unit was referred to more frequently than in the previous lesson.

(iii) Most of the questions asked were of the recall type, problem solving questions were also asked throughout the lesson.

(iv) Clarification of concepts was requested by the pupils on fewer occasions compared to the previous lesson, and no questions were asked involving clarification of the teaching instruments used.

(v) Most of the questions posed by the teacher were

TABLE 5.5 Geography teacher observation schedule for the lesson on mid-latitude depressions

	Minutes 0–5	5–10	10–15	15–20	20–25	25–30	30–35
SECTION A							
1. Reference made to real world	✓	✓	✓	✓			
2. Topic definition	✓✓						
3. Use of key concepts	✓✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓
4. Use of models during the lesson:							
4.1 iconic (hardware models)	✓	✓		✓✓✓✓✓	✓✓		✓✓
4.2 cross sections			✓	✓	✓	✓	
4.3 weather types (teaching units)	✓	✓✓	✓	✓✓	✓	✓✓	✓
4.4 synoptic charts	✓	✓				✓	
SECTION B							
1. Teacher input:							
1.1 questions leading to:							
recall of facts	✓✓	✓	✓	✓	✓✓✓✓✓	✓	✓✓
problem solving			✓✓✓✓		✓		✓✓✓
1.2 requiring pupil participation i.t.o:							
direct observation		✓✓✓	✓	✓✓		✓✓	✓
interpretation		✓	✓				✓
application				✓	✓	✓	✓
2. Pupil input:							
2.1 information sought i.t.o:							
clarification of concepts	✓				✓		✓
clarification of instruments used							
other clarification				✓	✓	✓✓	
2.2 questions answered	✓✓	✓✓✓	✓✓✓✓✓	✓	✓✓✓✓✓✓	✓	✓✓✓✓✓✓

responded to by the pupils, and more questions were asked in this lesson than in the previous lesson.

The non-participant observer commented that the pupils were probably confused by the air sector labels 'colder' and 'coldest' on the hardware (polystyrene) model of the cold front occlusion.

Comments and discussion

The mid-latitude depression is a very complex weather system involving many concepts: hence, the greater use made of the key concepts, the iconic models and the weather type unit.

The lesson was made more meaningful by the fact that a coastal low and frontal depression had passed over East London the preceding weekend. Reference and application of weather type concepts to the real world were facilitated.

In small-scale research such as this, it is difficult to perceive the benefits of the strategies employed with any certainty. A further complicating factor relating to this is the difference in degree of difficulty between the coastal low and the mid-latitude depression, which created an additional variable that could not be accounted for or tested.

5.3 RESULTS OF THE TESTS

The nature of the tests and marking memoranda have already been described in Chapter 3. The results of those pupils who were absent for any one of the lessons have been omitted to facilitate comparisons between the two tests and because those who missed the first test will have been disadvantaged in the second test. Unfortunately no school tests, against which comparisons could be made, were written on southern African climatology previous to the conducting of the research.

The marks awarded for each test to each pupil are indicated in Table 5.6 below.

TABLE 5.6 Marks for the two tests

PUPIL	MARKS TEST 1 (%)	MARKS TEST 2 (%)	TOTALS (%)
1	92	70	82
2	76	80	78
3	92	60	78
4	76	70	73
5	72	30	53
6	76	25	53
7	48	50	49
8	48	45	47
9	44	30	38
10	76	absent	not used
11	absent	55	not used

Evaluation of the tests

An analysis of the pupil's marks for each question is shown in Table 5.7 and in the graph (Figure 5.4) below. By converting the total marks scored by all the pupils for each

TABLE 5.7 Analysis of total scores in the two tests.

	Qu 1	Qu 2	Qu 3	Qu 4	Qu 5	Qu 6
Allocated marks for each question	2	3	7	1	12	20
	0	3	4	1	4	9
	1	3	2	1	12	5
	0	3	7	1	12	14
	1	3	2	1	12	16
	0	3	4	0	4	6
	2	3	7	1	10	12
	1	3	5	1	8	6
	0	3	0	1	8	10
	0	2	5	0	12	14
Total score by all pupils for each question	5	26	36	7	82	95
Possible total score for each question	18	27	63	9	108	180
% of possible total score	27,78	96,3	57,14	77,79	75,93	52,78

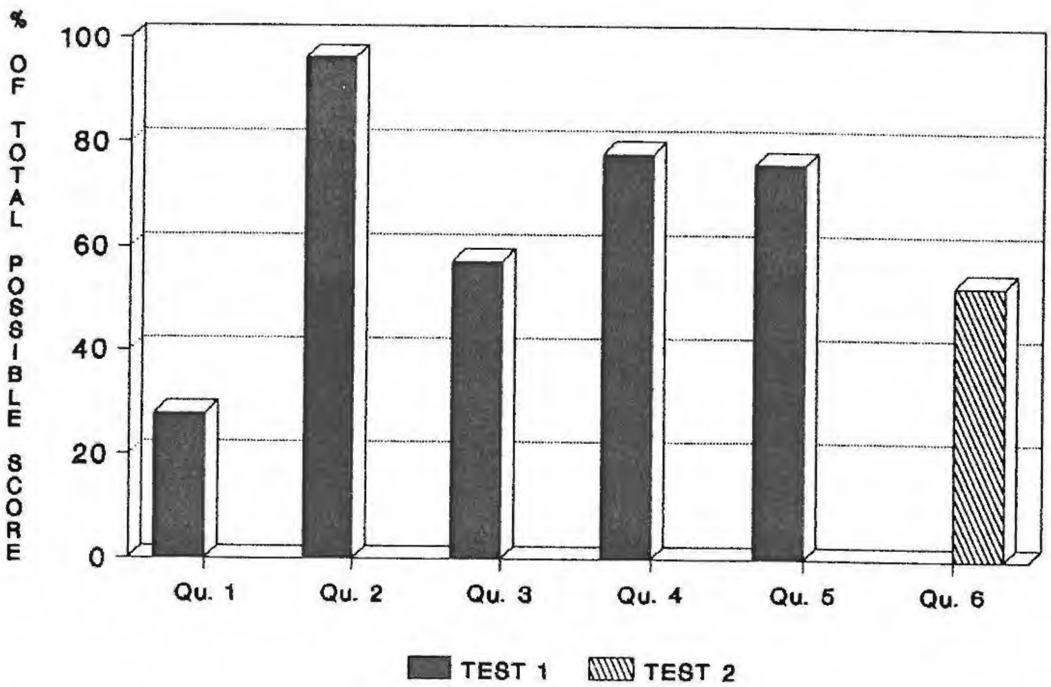


FIGURE 5.4 Percentage of possible total scores attained by the pupils for each question in the two tests

of the questions in both tests to a percentage of the possible total for those questions, it is possible to judge which questions were poorly answered. The first five questions comprised the first test, while question six comprised the second test.

The results indicate that the pupils had the greatest difficulty with answering question 1 on the seasonality of the coastal low. As far as the weather changes (question 3) are concerned, they were able to attain only 57,14% of the possible marks as the answers lacked the detail necessary for a full explanation. They had the least difficulty with the origin and migration of the coastal low, its relation to the frontal depression, and, the synoptic representation of its migration and influence on coastal weather (questions 3, 4 and 5).

Question 6 consolidated what was taught on the two types of depression by testing their interpretation of the synoptic chart. A little over half the possible marks were scored.

Comment and discussion

The poor performance in Question 1 regarding the reason for the coastal low's being best developed in winter suggests that they were unable to associate the coastal low with anticyclonic circulation and strong offshore flow of air at higher altitudes. To answer the question required analytical skills in which the whole is broken down into its parts in order that cause and effect relationships can be seen. (Nowlan, 1990; Stenhouse, 1975). Cylindrical models and a relief model of southern Africa were used to demonstrate the parts of this weather phenomenon and their relationships from the front of the classroom. It might have helped to have had the pupils manipulate and experiment with the models themselves in order that they see the associations from their perspectives. It is thought that the participation of the pupil in model making involves a clarification by the builder of the concepts that the model is intended to illustrate (Gopsill, 1973:231). The researcher surmises that the same benefit may be derived through active manipulation of already constructed models.

The place of origin and the path followed by the coastal low in Question 2 was grasped by almost all the pupils. The question asked required little more than the recall of facts which were reinforced during the lesson by the use of both hard models and overhead transparency overlays, as described elsewhere. A case can be made for greater use of sequencing, ie. showing the development of weather patterns over a few days. This technique was also used in the lesson on frontal depressions to illustrate the three-phase weather conditions experienced with the approach of the cold front. Test results indicated that the pupils had little difficulty with the relationship and differences between the two types of depression and with their synoptic representation.

In Question 4, the association of the coastal low with the approach of a frontal depression was tested. The answer to this question requires the skill of prediction and the pupils fared well with this question.

Question 5 tested the pupils' ability to construct a synoptic chart and to forecast a change in the isobaric patterns and weather conditions over a two to three day period. Answers revealed some careless errors such as neglecting to label all the pressure cells and the weather conditions. The likelihood exists that had the pupils read the question properly, higher marks would have been attained.

The longer questions (Question 3 in the first test, and the question comprising the second test) were not answered as well as the researcher had hoped. The questions were designed to bring together the various aspects of each weather type and to make predictions. To answer the questions adequately, requires synthesis skills on the part of the pupil in which the parts of the whole are distinguished and formulations are made from a Gestaltic viewpoint (Nowlan, 1990; Van Jaarsveld, 1988). Three reasons could account for the mediocre performance in the consolidation questions:

(i) Van Jaarsveld (1988) identifies retroactive inhibition as a problem for chronologically mature formal thinkers, where the smaller features are dominated by the macro-view "resulting in the inability to synthesise sufficiently to make well-reasoned formulations or forecasts" (p. 58). Performance could have been improved had the question been broken down into sub-sections by supplying the pupils with sub-headings. In this manner pupils inexperienced in synoptic chart interpretation are coached into breaking the greater picture down into its components before attempting analysis and synthesis.

(ii) The pupils were unable to do justice to the test because they could not be given adequate time to prepare for the test as a homework exercise.

(iii) The first test was written at the end of a tiring seven hour day.

5.4 THE EVALUATIONS OF THE COURSE AS A WHOLE

The two-lesson course as a whole was evaluated by the pupils using a semantic differential, and by the non-participant observer guided by the observation schedules.

5.4.1 Results of the semantic differential

The scores within the three categories significance attribution, involvement and experience, as well as the totals and averages are set out in Table 5.8 and in the graphs (Figures 5.5 and 5.6) below.

TABLE 5.8 Scores attributed to each item within the three categories of experience, involvement and significance attribution.

	EXPERIENCE					INVOLVEMENT					SIGNIFICANCE ATTRIBUTION					INDIVIDUAL AVERAGES		
PUPILS	Pleasantness	Relaxation	Fulfillment	Achievement	Satisfaction	Interest	Ease	Involvement	Challenge	Identification with content	Logicality	Clarity	Intelligibility	Relevance	Reality	Experience	Involvement	Significance Attribution
A	3	4	4	4	4	3	3	1	4	4	3	4	5	4	4	3,8	3,0	4,0
B	4	5	5	4	4	4	4	3	3	4	5	5	5	4	5	4,4	3,6	4,8
C	4	4	4	4	5	5	5	3	3	4	5	5	4	5	5	4,2	4,0	4,8
D	4	5	4	5	4	4	5	5	3	4	5	5	5	5	5	4,4	4,2	5,0
E	5	5	5	3	4	3	3	5	4	3	4	5	4	5	5	4,4	3,6	4,6
F	4	3	4	5	5	5	4	5	4	5	5	5	5	4	5	4,2	4,6	4,8
G	5	5	4	4	4	4	3	4	4	4	5	4	4	5	5	4,4	3,8	4,6
H	4	4	4	4	4	3	4	4	4	4	4	5	4	4	4	4,0	3,8	4,2
I	4	5	4	3	4	3	4	3	3	3	3	4	4	5	4	4,0	3,2	4,0
	4,11	4,44	4,22	4,00	4,22	3,78	3,89	3,67	3,56	3,89	4,33	4,67	4,44	4,56	4,67	ITEM AVERAGES		
	4,2					3,76					4,53					CATEGORY AVERAGES		

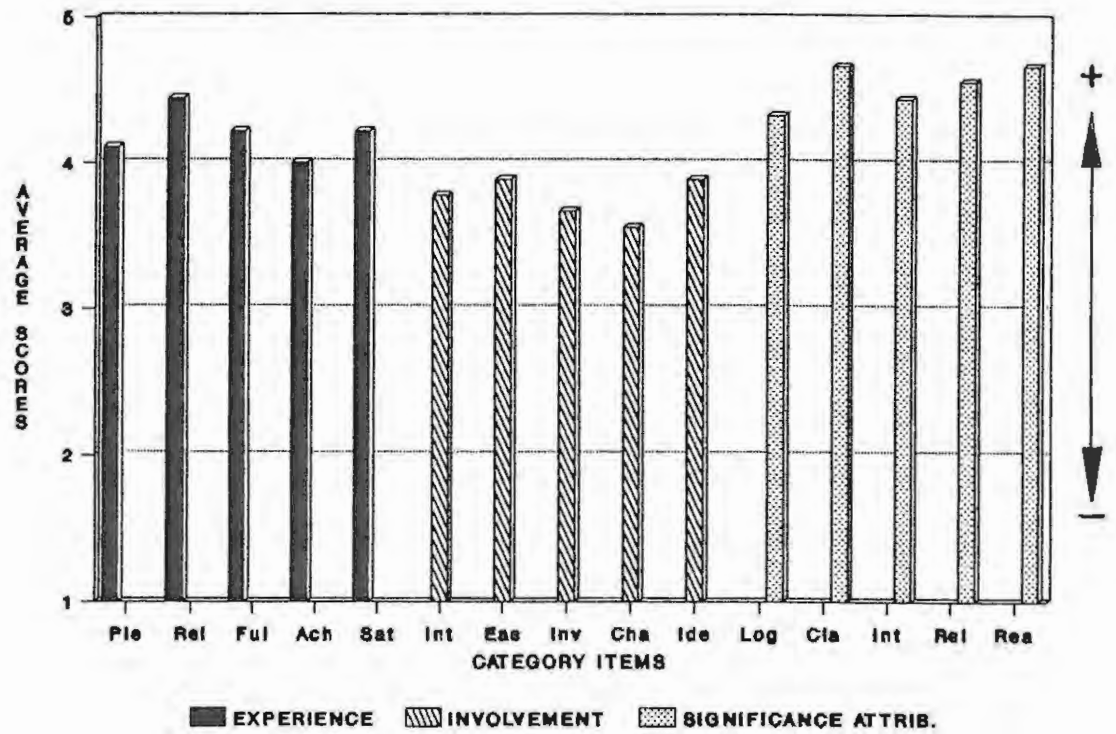


FIGURE 5.5 Average scores for the items within the categories experience, involvement and significance attribution

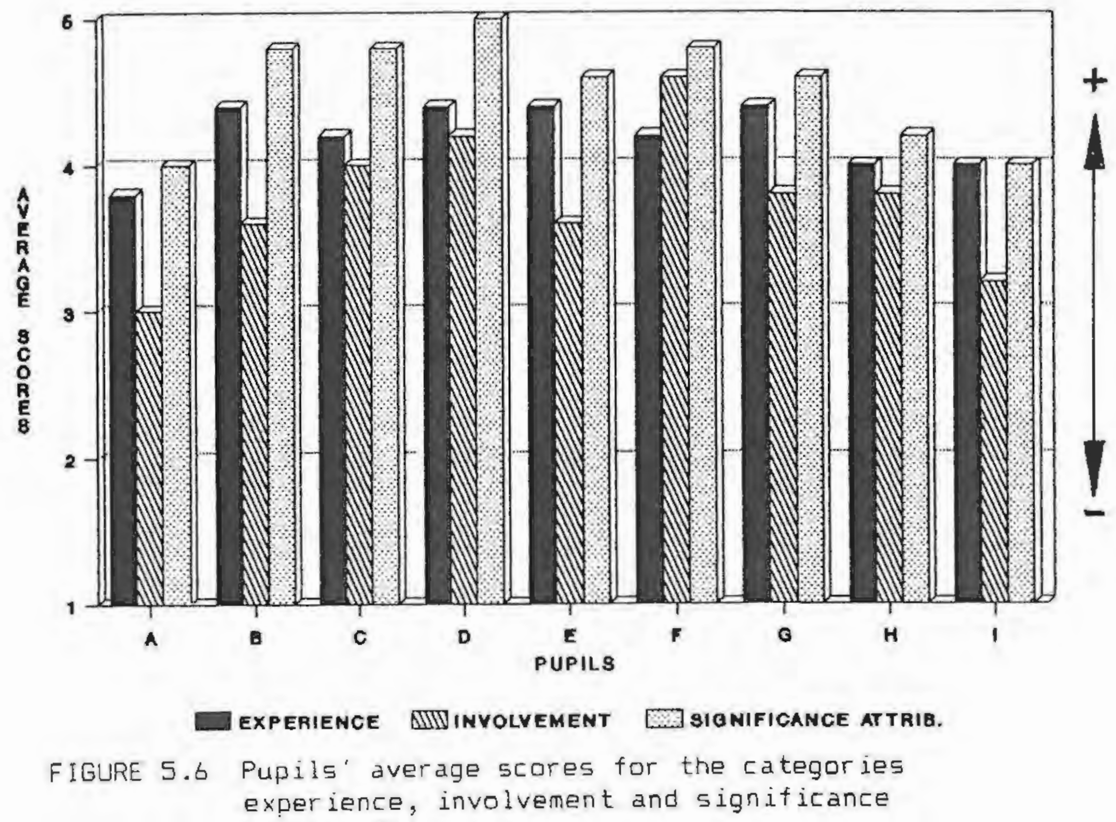


FIGURE 5.6 Pupils' average scores for the categories experience, involvement and significance attribution

Evaluation of the semantic differential exercise

The average scores attributed to the group's experience of (4,2) and significance attributed to (4,53) the course as a whole are high. In other words, almost all the pupils experienced a high degree of fulfilment, achievement and satisfaction and found the course pleasant and relaxed. With regard to the significance attributed to the course, almost all the pupils found the course to be very logical, clear, intelligible, relevant and realistic.

The group's involvement in the course was not as positive as the other two categories. Only one pupil found his involvement to be passive. Generally, the group found that the course was easy, challenging and interesting, that they could identify with the content, and that they were actively involved to a fairly high degree.

Comments

It has already been stated that the weather type units were devised for mass instruction. Mass instruction has the disadvantage of relying on pupil passivity at the expense of pupil activity, and this may partly explain why pupil involvement reflected a lower score.

The lower score for involvement could also be attributed to the limited time that was available to conduct the lessons, rather than to any deficiency in a model-based teaching strategy. It would be more realistic, in the author's opinion, to assess the degree of pupil involvement over the entire climatology course under less artificial circumstances with the pupils' actual teacher.

5.4.2 The non-participant observation summary

The observation schedules (Table 3.1) for each of the lessons were used by the non-participant observer as a guide for the completion of the observation summary (Table 3.3).

Results

The various models used in the lessons were evaluated under the separate headings of cross-sectional diagrams, synoptic weather maps, weather type models (teaching units), and iconic models (hardware models). The aspects evaluated included the reflection of the fundamentals, reduction of illustrative noise, visual appeal, enhancement of three-dimensional aspects, integration of concepts, relevance to the syllabus and southern Africa, and the potential for conceptualisation.

All the models received ratings of good and excellent with regard to the items listed. The iconic models were rated as excellent in every respect.

The comment was made that colour would help to improve the cross-sectional diagrams, weather type models and synoptic charts - this opinion was voiced by one pupil as well. A valuable suggestion made by the non-participant observer was that both colour and monocolour synoptic charts ought to be used so that pupils are able to associate the weather type synoptic chart with black-and-white newspaper synoptic charts and colour television weather maps.

The potential for the enhancement of three-dimensional visualisation and for conceptualisation was regarded as excellent with respect to the iconic models because the pupils were able to 'see' the invisible elements of climate and their interrelationships. The iconic models used to teach the berg wind weather type were especially valuable in this regard. The teacher regarded the use of iconic models as novel and very effective.

The use of the models by the author was also evaluated in terms of visibility, integration with climatic concepts, pupil prediction of changes with the manipulation of the models, distinctions made between the model and reality, and the stimulation of pupil interest and inquiry. All the items received high ratings. A last aspect was the respect for differences in pupils' perceptual awareness, which was rated as satisfactory. This item was found difficult to evaluate.

Teacher-pupil interaction during the lesson was also evaluated. Pupil interest and participation in the lesson and their apparent assimilation of concepts were rated as good. Their inquiry and spontaneity in answering questions were regarded as satisfactory, the strangeness of the temporary teaching-research situation that they found themselves in may have caused a measure of reticence on their part.

The researcher's interaction skills were evaluated in terms of clarity in explanation, integration of concepts, pitching the lesson at the pupils' level, progression from simple to complex concepts and the dovetailing of concepts, models and synoptic charts. All these aspects received high ratings.

The development of the skills as set out in the senior secondary geography syllabus were evaluated as satisfactory in the case of literacy and numeracy, and, as good with regard to graphicacy, logicality and interpretation of illustrative material. The application of skills to new situations and the development of perception of reality were judged excellent. The development of cognitive skills, as listed in Bloom's taxonomy, was judged good.

On a general level, reference made to real world situations was good - this was confirmed by the pupils' evaluations. Clarity and the coverage of key concepts were described as excellent.

Comments

The overall impression gained from this observation summary is that the lessons were highly rated. There appears to be a dovetailing of the pupils' evaluations and the non-participant observer's evaluations with regard to the use of the various models in the lessons. The value of the weather-type units themselves was appreciated more by the non-participant observer than by the pupils, who nevertheless also rated them highly.

5.5 SUMMARY

With reference to the purpose of the weather type models set out in Chapter 4 the following conclusions can be drawn:

1. The purpose of the standard 10 exercise was to establish whether the pupils' visualisation of the particular weather type could be enhanced resulting in better performance. This was a one-off exercise, so that the other objectives listed in Chapter 4 do not apply. The answers appear to reflect that the use of the weather type model did not improve the pupils' learning performance in southern African climatology. It must be stressed though, that use of the theoretical model requires skills that have to be taught. On their own, without prior training and support from strategies and aids such as hardware models, the theoretical models cannot be expected to accomplish their objectives.
2. The standard 9 tests showed that the pupils were able to

establish and consolidate satisfactorily the major components comprising the two weather types in a synoptic chart context. They were able to interpret the synoptic chart competently in the final question; but again, had the pupils been given more experience with the weather type models the problems of retroactive inhibition described in Chapter 4 may have been alleviated.

3. The results of the standard 9 evaluations, the non-participant observation schedules and the semantic differential paint a more positive picture. The non-participant observer's opinions confirmed the pupils' evaluations to a large extent. The use of the models was regarded as novel and of value. The overall pupil experience of and significance attributed to the lesson were very positive, and their involvement in the lesson was positive. As far as the specific purposes of the weather type models are concerned, it appears from the evaluation instruments that all the objectives were attained.

4. The anomaly between the test results and the evaluations may be attributed to the following:

(i) The teaching setting was artificial. The pupils were not familiar with the participant teacher, nor with the new teaching strategy that was used.

(ii) The models were not used through the entire climatology course.

(iii) The research procedure itself imposed constraints on the research. For example, the time available to teach the lessons was limited by the need to complete the tests and evaluations.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

This research was concerned with the effectiveness of a teaching approach employing weather type models to improve the adolescent pupil's conceptualisation of S.A. climatology-meteorology in the context of the synoptic chart.

Recent research reveals that there are graphicacy and perceptual-conceptual problems in the reading of the synoptic chart similar to and often greater than those encountered in mapwork. It is clear that pupils have difficulty in perceiving three-dimensionally the abstract climatological concepts and processes embedded in the synoptic chart. Conceptualisation and perception are intimately connected and the developmental theories of learning reveal that conceptualisation is geared to cognitive maturity and is accomplished through progressive phases. The problem faced by the concrete thinker in the senior secondary school is that of internalising abstract concepts that are better suited to more mature pupils. The problem is exacerbated by syllabus fragmentation, the lack of carefully planned progression in the syllabus, the temporal nature of weather patterns, and, by deficient teaching strategies.

Models, by their nature, reduce inessentials and are a generally accepted means of introducing complex abstractions in order to aid pupil understanding. In examining solutions to the perceptual-conceptual difficulties that pupils have in understanding synoptic maps, this study used model theory to develop a series of theoretical and hardware models suited to the explanation of weather patterns in the southern African context.

The theoretical models designed incorporated side views, plan views and key facts in such a way that a progression through degrees of abstraction from iconic to symbolic modes of representation, as well as a conceptual progression from simple to complex weather types are achieved. Hardware models were designed as supporting aids.

When tested and evaluated in a classroom situation, these models revealed the following with regard to their value as a teaching strategy.

(i) Under the circumstances prevailing at the time of the research, it could not be quantitatively proved that a model-based approach bettered a pupil's learning performance in southern African climatology

(ii) It appears that the effective use of the weather type models as a learning device requires that skills first be taught before the pupil is able to interpret the models. The model cannot take the place of the teacher.

(iii) It cannot be assumed that because other types of model, such as hardware models, were used in previous years, that standard 10 pupils are able to use theoretical models without first being taught the skills associated with their use.

(iv) The pupils had least difficulty with the relationship between the two types of depression and with their synoptic representation.

Based on the evaluations of the pupils and non-participant observer, the following were indicated:

(i) Weather-type and iconic models in southern African climatology were novel to both teacher and pupils and were well received according to the evaluations made.

(ii) Application of the climatology section to the world of experience was appreciated by the pupils.

(iii) The visualisation of the three-dimensional aspects of Southern African climatology was enhanced.

(iv) No pupils felt that the model did not aid their general understanding of the weather types. A clear majority found their understanding was aided fully.

(v) No pupils felt that the models stifled their interest and enjoyment and the clarity of the lesson.

(vi) Few pupils (approximately 2%) encountered difficulty in understanding specific key concepts.

(vii) The experience of and significance attributed to the lessons were very positive; involvement in the lessons was positive.

(viii) The value of the weather-type units was appreciated by the non-participant teacher.

In the light of the aforegoing, it would seem that:

(i) A model-based teaching approach to S.A climatology ought to reflect a progression that accommodates the cognitive development of the pupil.

(ii) Greater use ought to be made of models (hardware and theoretical) in the teaching of S.A. climatology for the reasons already discussed, and the effective use of the theoretical weather type models as a learning device requires that the pupils be taught skills necessary to interpret and use the models. The model cannot take the place of the teacher.

(iii) It was suggested that pupils ought to be more involved in the lesson and that pupil-centred learning based on self activity has its merits. Therefore, rather than confining the use of the hardware model to the teacher, pupils would have a better grasp of the models if they are given opportunity to build and manipulate them themselves. In this manner close attention can be given to the principles which they represent.

(iv) Analysis skills should be developed by breaking macro-patterns into smaller units. In this manner the pupil is guided through the mass of information presented by the synoptic chart.

(v) The teaching of weather patterns and processes should always involve a synoptic chart representation only after the patterns and processes have been taught using more concrete means such as models and cross-sectional diagrams. The use of visual representation ought to reflect the Brunerian sequence progressing from the enactive mode (reality), to the iconic mode (picture or diagram) and culminating in the symbolic mode (map representation).

(vi) Reference ought to be made to the real world as much as possible. Case studies of a recent weather phenomenon in southern Africa or a study of the local weather based on synoptic chart interpretation would root the exercise in reality and offer opportunities for pupil-centred teaching.

(vii) Since weather sequences facilitate the understanding of the dynamic and everchanging nature of weather, synoptic charts from the daily newspaper can form the basis of a lesson. Another useful exercise involves the sorting out of a number of synoptic charts into a time sequence.

(viii) Simulation games are known to inject a measure of enjoyment in geography learning. There appears to be scope for the development of simulation games in the context of the climatology section of the syllabus.

There is a need for the development of teaching strategies associated with the teaching of S.A. climatology, in order that lessons become stimulating and meaningful. Pupils are often overwhelmed by the abstract and seemingly unrelated components of the climatology syllabus. Models, and weather type models in particular, provide a receptacle for meteorological-climatological data and patterns in one view. The weather type models researched in this study were well received by the teacher and pupils concerned. Admittedly, the scope of this case study, which is essentially a pilot study, is limited; but it does provide some insights into an area requiring further research.

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APPENDIX 1

EAST LONDON'S WEATHER

EXERCISE 1

You are required to make detailed weather recordings for East London from Monday 4 March 1991 to Sunday 10 March 1991. For the sake of uniformity, you are requested to make use of the simplified daily synoptic map appearing in the "Daily Dispatch" and your own observations. The SATV gives the expected calculated temperatures for the following 24 hours and not those actually recorded as the newspaper does. Make a table as shown below for your recordings.

TABLE 1. RECORDINGS OF WEATHER STATISTICS IN E.LONDON (4 MARCH - 10 MARCH 1991)

Date	General comments on weather conditions	Temperature °C		Humidity %	Air pressure hPa	Precipitation type	Max Av wind speed km/h	Wind direction	Clouds	
		Max	Min						Type	Cover oktas
eg 2/5	Cloudy and cool in the morning. Warm and clear in afternoon with fresh breeze.	24	14	63	1007	None	10	SE	Cu	7

Use the cloud type diagram in your text book to help you identify the cloud types. You may consult the very good photographs of the different cloud types in Juta's Magister Atlas (p. 11).

N.B. You must record the cloud types at 12:30 each day.

EXERCISE 2

Draw East London station models similar to those in your text book for Monday 4 March, Wednesday 6 March and Friday 8 March using the information that you accumulate.

EXERCISE 3

Construct a wind rose for the week's wind recordings using the maximum average wind speeds and directions recorded in the newspaper.

APPENDIX 2

WEATHERSHIPS

How the game is played.

1. The game is played with two pupils. One pupil (the respondent) is given a completed weather map while the other (the caller) is supplied with a map outline with a grid superimposed on it.

2. The caller calls out a square, the respondent gives him all the information contained in that square. Using the example below, if f3 is called, the response is: 'pressure 1006 hPa, 8 oktas cloud, SW wind, 1410 meters' - no other information is given.

3. The caller pieces together all the bits of information and attempts to construct the map.

4. The teacher may limit the number of calls made depending on the ability of the pupils or on the accuracy of the map required at the end of the exercise.

5. A good map showing the main features and approximate isobaric patterns is required at the end of the simulation.

6. Weaker pupils can be given guidance for the game on frontal depressions such as :

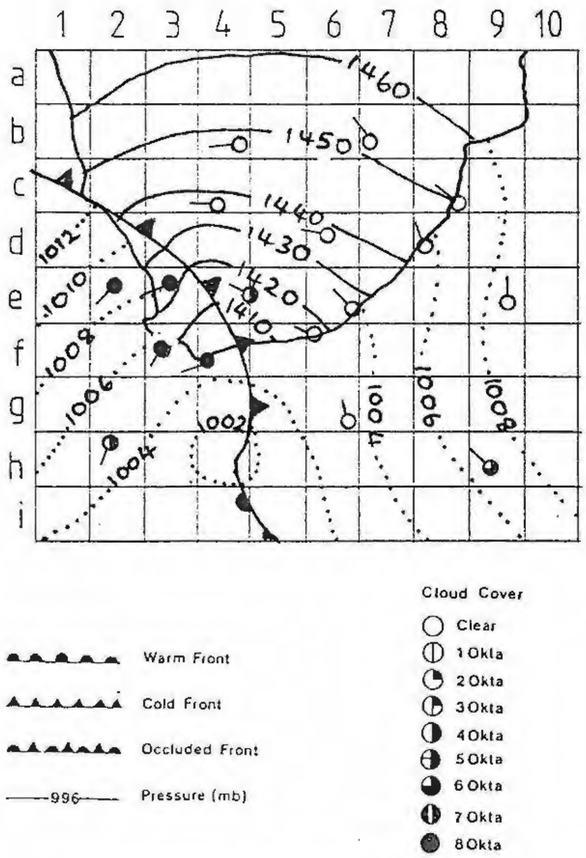
Remember:

i. pressure decreases towards the centre of the depression;

ii. wind spirals into the centre of a depression in a clockwise fashion in the southern hemisphere;

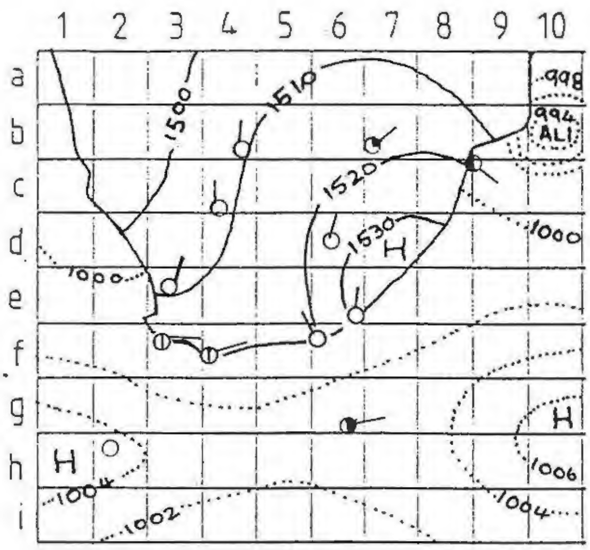
iii. cloud cover increases towards the centre of depressions and over fronts.

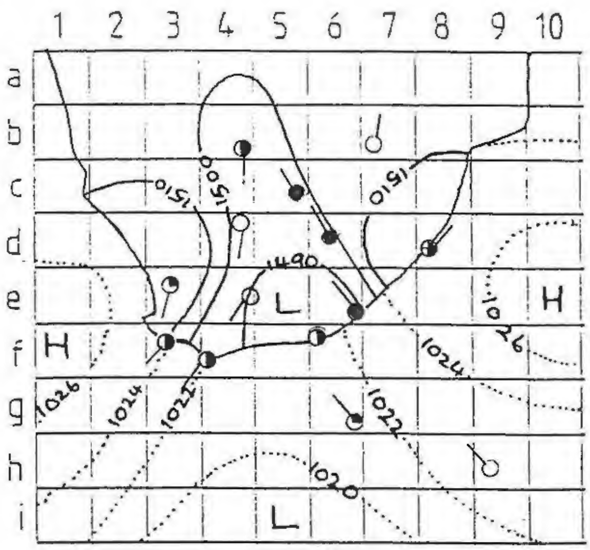
iv. fronts join at the centre of a depression and a warm and cold front meet to form an occluded front.

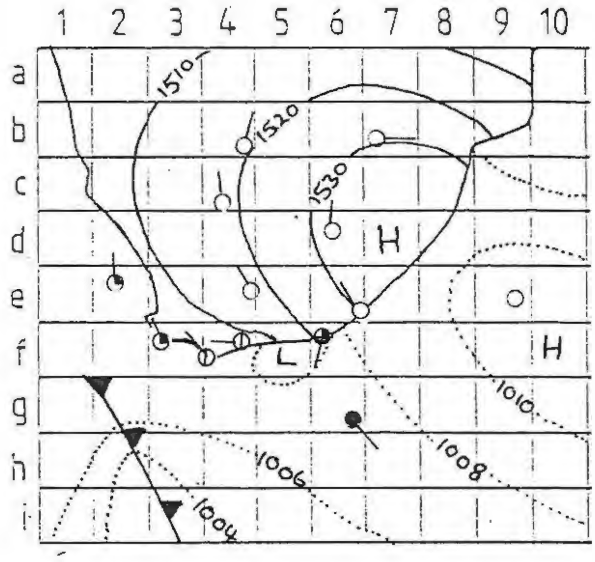


THE COMPLETED MAP

THE BASE MAP







<u>COMPLETED WEATHER TYPE MAPS</u>

APPENDIX 3

THE S.A. DEPRESSION GAME

The depression is divided up into 9 sectors and the weather conditions in each of the sectors is given in the key. For example, in sector 2 the rainfall is heavy, the air temperature is 12°C, some nimbostratus cloud occurs, pressure is steady for a short time, and it is calm. Three marginal zones (X, Y and Z) are found around the outer edge and weather conditions in these areas are shown.

How the game is played.

1. The pupil writes his name and that of the station (one of the shaded areas on the base map is chosen) for which he is forecasting.
2. A transparency with the depression model drawn on it is placed over the base map with the C square over the letter C on the base map.
3. Using the weather keys, the actual weather conditions experienced at the station are recorded on the record sheet
4. A forecast for the next 2 hours is filled in on the record sheet. The depression can be moved around temporarily to work out how conditions may change.
5. Two dice are thrown and the depression moved in the direction indicated by the movement matrix. For example, if a 9 is thrown then the depression is moved SE by one block.

6. The actual conditions are then worked out and written onto the record sheet and compared to the previous forecast. The forecast is marked right or wrong in the last column on the record sheet.

7. An arrow is drawn on the base map indicating the course the depression has taken.

8. The process is repeated for all ten rounds, the correct forecasts are counted and a zero is added to give the percentage success.

WEATHER KEYS FOR THE DEPRESSION MODEL

HEAVY	DRIZZLE LONG CLEAR SPELLS	HEAVY
VERY HEAVY	DRIZZLE SHORT CLEAR SPELLS	VERY HEAVY
HEAVY then CLEAR	HEAVY	DRIZZLE and RAIN

RAINFALL

11	14	10
10	13	9
8	12	7

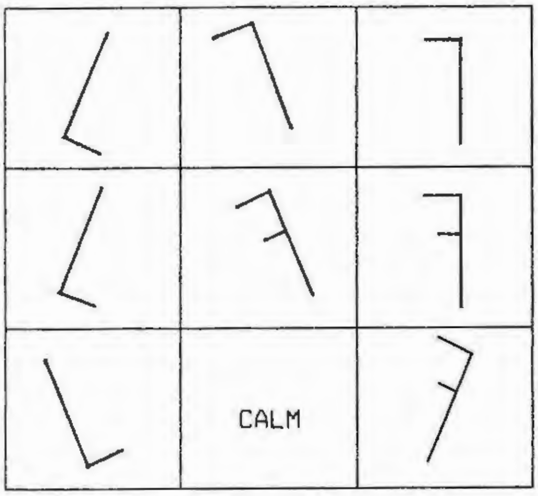
TEMPERATURE °C

NIMBO-STRATUS	STRATUS and some CUMULUS	NIMBO-STRATUS
CUMULO-NIMBUS	STRATUS	NIMBO-STRATUS and STRATUS
CUMULUS	some NIMBO-STRATUS	STRATUS AND ALTO-STRATUS

CLOUD TYPE

RISING	STEADY for LONG TIME	FALLING
RISING FAST	STEADY	FALLING FAST
RISING then STEADY	STEADY for SHORT TIME	FALLING SLOWLY

PRESSURE



WIND DIRECTION

X	Infrequent drizzle, 8°C, cirrus cloud, pressure falling slightly, NNE wind, 5 knots.
Y	Clear, 16°C, scattered stratus cloud, pressure steady, NW wind, 5 knots.
Z	Showers, 9°C, fair weather cumulus, pressure steady, SSE wind, 5 knots.

WEATHER IN MARGINAL ZONES

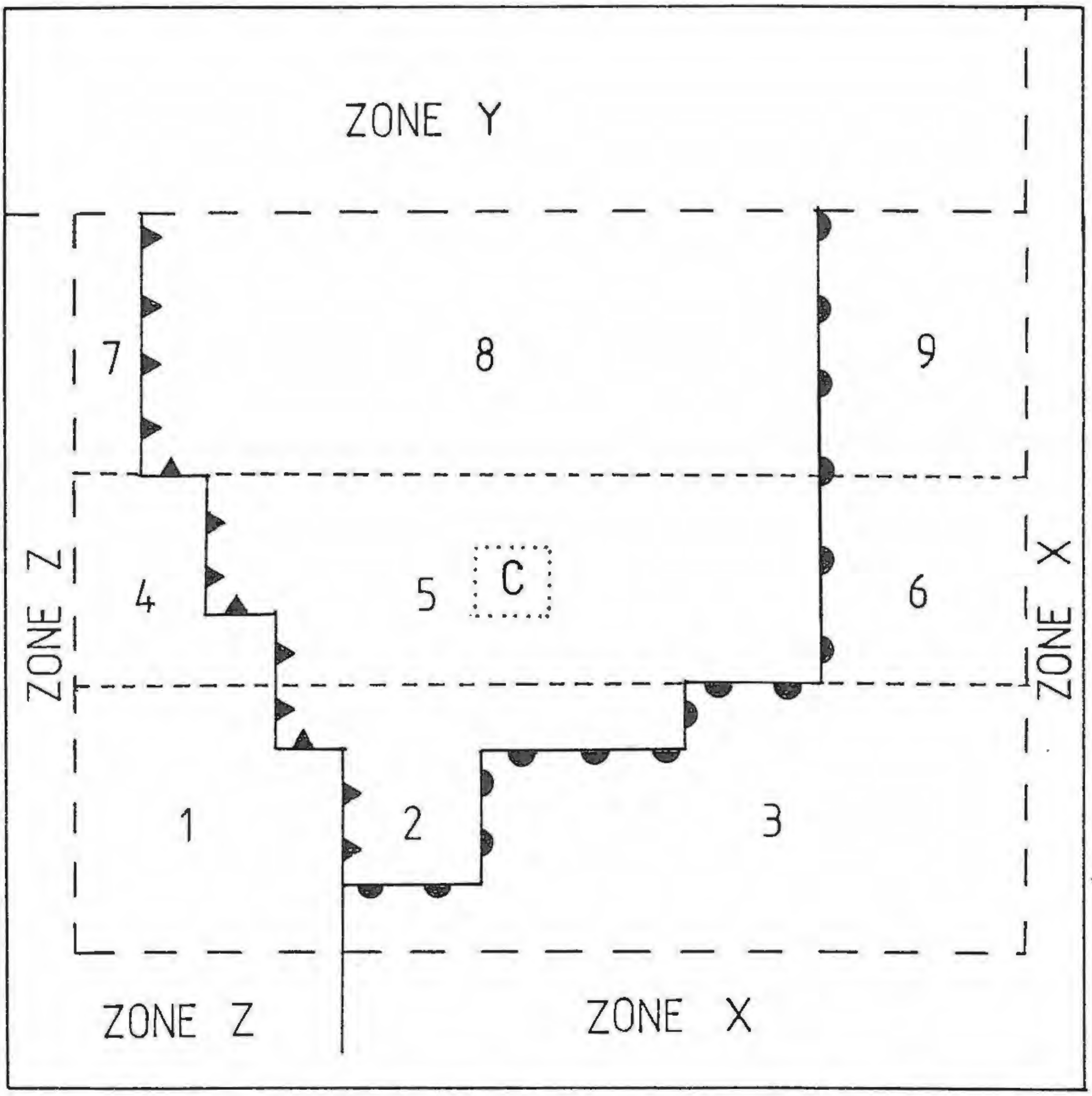
<u>MOVEMENT MATRIX</u>

12	11	6	
	10	5 7 and 8	2
3	4	9	

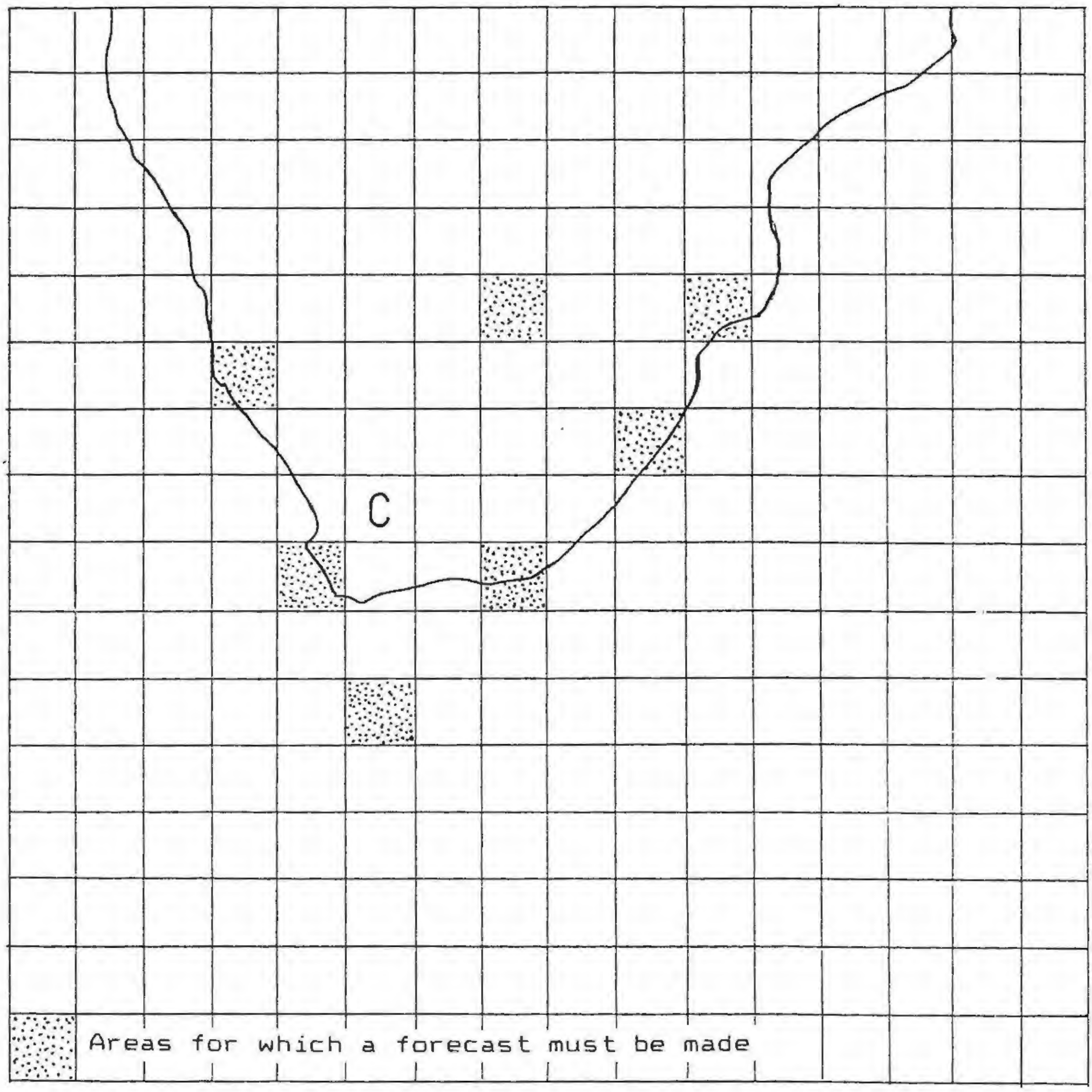
The centre box (10) coincides with the 'C square' on the depression model.

If 10 is thrown, the model is not moved; if 5, 7 or 8 is thrown, move the model one block eastwards across the map.

DEPRESSION MODEL



BASE MAP



RECORD SHEET

AREA ______________	FORECAST					ACTUAL WEATHER					Right or Wrong
START	Forecaster ____________________________										
2 hrs											
4 hrs											
6 hrs											
8 hrs											
10 hrs											
12 hrs											
14 hrs											
16 hrs											
18 hrs											
20 hrs											
	Rainfall	°C	Cloud type	Pressure	Wind direction & strength	Rainfall	°C	Cloud type	Pressure	Wind direction & strength	