Using primary school children's cognitive map representations as a means of measuring their overall general mapping ability

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by Jacqueline Ellen Wickstead

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To George

"I love you more than the World"

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Abstract It is always good geographical practice to start with what is on one's own doorstep. The starting point for this research is even nearer than that. It starts with the child's own internal cognitive map. This research (working within a Piagetian paradigm) attempts to use primary school children's cognitive map representations (drawn and verbal) of two different but familiar large-scale environments as a means of measuring their overall general mapping ability. One of the aims was to construct an instrument that could be used by teachers in their classrooms that would produce reliable and generalisable judgements of primary school children's overall general mapping ability. For the purpose of this research, Hart and Moore's (1973) definition of the term cognitive map representations as including drawings; published maps, vertical aerial photographs, verbal reports and models will be used. The definition for overall general mapping includes separate variables relating to stages of development, cartographic concepts, cartographic features, verbal directional and environmental perception responses, the interpretation of large-scale Ordnance Survey maps and vertical aerial photographs. Although separate variables have been identified and methods developed for their assessment, to date there does not seem to have been an attempt to find an overall general measure.

The research questions were "Can a method be developed to measure children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" In addition, "Should an emergent stage be included to accommodate children who could not be placed into a stage of development. Finally, because there is still speculation concerning gender, the question "Are there gender differences in mapping ability?" was also considered.

The population comprised three schools and a stratified sample of six boys and six girls from each of the seven primary year groups (252 children). The children were asked to draw maps of two different but familiar large-scale areas, to verbally describe a route on each map, indicate their environmental perception responses, identify features on large scale Ordnance Survey maps and vertical aerial photographs of both familiar areas.

The stages of development variable, producing a qualitative measure, although inter-related, was not compatible with the other variables producing a quantitative measure. This was considered as a separate variable and used as an indicator of any correlation between stages of development and the variables producing a quantitative measure. Although the results relating to the stages of development variable highlighted complexities, the majority of children's drawn cognitive map representations were placed at the projective one stage of development. The results of the overall general mapping ability variable showed that, for the sample as a whole, the mean of pupil performances on Map Area B was significantly higher than the mean of Map Area A. Although there is still speculation about gender differences the results showed that there were no significant differences between girls and boys overall.

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INTRODUCTION

It is considered good geographical practice to start with what is on ones own doorstep. The particular 'doorsteps' that provide the starting points for the research reported in this thesis include my own context as a primary school teacher of many years of experience with a passion for geography teaching which I sustained for as long as I was teaching and beyond. The other starting point is the children's internal cognitive map. As a teacher, I was interested in how it might be possible to use primary school children's cognitive map representations as a means of measuring their 'overall general mapping ability'. The aim of the research was to construct an instrument that could be used by teachers in their classrooms, which would assist them in their planning, teaching and assessment in this fascinating, but often neglected area of the curriculum.

The research (working within a Piagetian paradigm) examines the possibility of using primary school children's cognitive map representations (both drawn and verbal), relating to two different but large-scale familiar areas, as a means of measuring their general mapping ability. For the purpose of this research, the definition that children's cognitive map representations are the external products of children recalling and reconstructing internal processes of their experiences of places which are familiar to them is used (Catling 1978; Boardman 1990). Hart and Moore (1973) suggest that these external products include drawings, published maps, vertical aerial photographs, verbal reports, and models. Verbal responses are important because some children are able to describe in more detail what they have depicted on their drawn cognitive map representation. For example, by describing a route in directional terms or identifying features depicted on large scale Ordnance Survey maps relating to the same geographical area as their drawn cognitive map representation. The construction of models (Piaget et al (1960) and movement in the large scale environment (Ottosson 1987, Blades and Spencer 1987 and Martland 1994) are other examples of these external products. Although models and movement in the large-scale environment can be used either as an alternative technique or reinforcement to the drawn cognitive map representation, they were not used in this research.

Different modes of enquiry such as drawn cognitive map representations (Catling 1978, Matthews 1992), verbal environmental perception responses (Hart 1979) Ordnance Survey map and vertical aerial photograph interpretation (Matthews 1989) and direction (Blades and Medlicott 1992) have been identified and methods developed for their assessment. It is clear that children respond differently when presented with problems framed in different ways (Piaget 1971) and consequently it cannot be assumed that a measure on any one variable can be extrapolated to form a measure of overall general mapping ability. However, to date there does not seem to have been an attempt to find a general measure and therefore the aim of this research was to construct an instrument to be used to produce reliable and generalisable judgments about primary school children's overall general mapping ability.
The research questions were "Can a method be developed using primary school children's cognitive map representations as a means of measuring children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" In addition, the question: "Should an emergent stage be included in the developing stages of drawn cognitive map representations?" was asked. Research by Wickstead (1991) showed that 15% of the children taking part in the study could not be placed into a stage of development, yet they had the ability to score in other variables relating to general mapping ability. Finally, because there is still considerable speculation concerning gender, the question: "Are there gender differences in primary school children's overall general mapping ability?" was asked. Although there is much evidence that boys are better than girls on some spatial tasks, and Matthews (1984a) produced results, which suggested that boys were superior to girls. This was different to Wickstead's (1991) research suggesting the opposite and O'Laughlin and Brubaker's (1998) research indicating that there were no gender differences in mapping accuracy.

For the purpose of this research, the population comprised three schools and a stratified sample of six boys and six girls from each of the seven primary year groups (252 children). In order to elicit the maximum amount of cartographic understanding and knowledge the children were asked to:

i draw maps of two familiar areas, a) their school perimeter (Map area A, and b) Another specified familiar area approximately two to three miles from their school. (Map area B)

ii draw a route on both maps and verbally describe the route (in directional terms) relating to Map areas A and B

iii draw ('happy/unhappy' faces) against some features on both maps and then verbally describe their likes and dislikes (and reasons) for the inclusion of these features

iv verbally identify features on Ordnance Survey maps (1:12500), and coloured vertical aerial photographs (1:1000). The maps and photographs were adjusted to ensure that they were approximately the same scale and identified the same geographical areas as the children's drawn cognitive map representations.

The structure of this report of the research comprises five chapters. Chapter One is concerned with an overview of the literature with particular regard to recording children's drawn and verbal responses relating to their cognitive map representations. There are two ways of measuring children's responses; one is concerned with qualitative changes and how groups of children progress from one stage of development to the next. The other is concerned with quantitative changes and how individual children can attain a quantitative score or total number of responses. The qualitative approach has been addressed by theorists such as Piaget (1955), Ladd (1970), Appleyard (1970), Hart and Moore (1973), Catling (1978) and Ottosson (1987). The quantitative approach has been addressed by theorists such as Lynch (1960), Hart (1979), Matthews (1985a), Blades and Spencer (1987), Weigand (1998) and Harwood and Usher (1999).

Piaget's theory of Euclidean spatial development was particularly relevant when attempting to place children's drawn cognitive map representations into stages of development. His findings suggested that there are three stages of development in the construction of Euclidean space, beginning with a simple topological type of relationship and following a gradual transition through to the projective and finally the Euclidean stage (Piaget and Inhelder 1956). Relating to Piaget's theory, the majority of primary school children are placed within the projective stage. Although Piaget defined this projective stage it is obvious that this stage covers a wide range of concepts. To overcome this issue, Catling (1978) redefined this stage by dividing Piaget's projective stage into a projective one stage and a projective two stage. Although Catling's method provided a more explicit method, Wickstead's (1991) results showed that in addition to there being a subjective element in the interpretation of the children's drawn cognitive map representations, some children could not be placed into a stage of development. However, Catling's (1978) qualitative method could also be used in a quantitative way, because it identified individual cartographic concepts such as direction, plan form, perspective and scale. Lynch (1960) provided a different method for recording different types of information from children's cognitive map representations in a quantitative manner. He proposed using major organisational elements of paths, nodes, landmarks, area, district and edges.

The principle aims of Chapter Two were to report the development of the instrument and its testing through a pilot study. The construction of checklists to record children's responses took into account the definitions of general mapping terms by (Catling, 1978 & 1981; Bale, 1987; Mills et al, 1988; Harrison and Harrison, 1989; Boardman, 1990; Weigand, 1993; Marsden and Hughes, 1994). Catling's (1978) illustrated overview was used as a guideline for placing cognitive map representations into stages of development, but with some reservations. It was considered important to make Catling's comments more objective by changing them into questions producing a "Yes" or "No" answer. An emergent stage was also included on the checklist to take into account Wickstead's (1991) research, when a number of children's drawn cognitive map representations were recorded as "non-scoring".

The construction of a checklist to record cartographic features such as roads, buildings and fields depicted on children's drawn cognitive map representations was based on Lynch's (1960) five major organisational elements of paths, nodes landmarks, areas or districts and edges. This scoring method was also used to record children's responses relating to the environmental perception; large-scale Ordnance Survey map and vertical aerial photograph variables. Harrison's' (1989) four stages of progression was used to record verbal directional responses.

The aim of the pilot study was two-fold, firstly, to test the feasibility of using the scoring guide and to make modifications to the procedures as necessary. Also to ensure that the methodology, when constructing the checklists for recording the children's responses were reliable, that the marking instructions were explicit and inconsistencies did not occur. Secondly, the pilot study was implemented to create an interaction between the children and the researcher. The importance of 'one to one' discussions was highlighted, as well as the children understanding what was being asked of them it was equally important for the researcher to understand the children's interpretation of their maps (Donaldson 1978).

Some modifications to the checklists were required. For example, although Lynch's (1960) organisational elements provided an objective method, two additional elements were included in the checklist. 'Ordnance Survey map' and 'discrete features' elements were included in order to accommodate features such as road names, railway embankments, 'the sandy slope' and 'the bus-stop'. Although features such as these were depicted on children's drawn cognitive map representations, they were not catered for in any of Lynch's (1960) five organisational elements of paths, nodes, landmarks, area and edges.

Chapter Three includes two problems both relating to the stages of development variable. Firstly, the interpretation and scoring of the drawn cognitive map representations showed that a substantial proportion of the children's maps could not be placed into a definite stage of development, but over-lapped between the projective one and projective two stages. Observations were made and hypotheses were considered for this over-lap. The first hypothesis was that the concept of the continuity of route was incorrectly placed within the projective two stage on the checklist and the second hypothesis was that the concept of perspective was incorrectly placed within the projective one stage of development. Some of the children had only depicted the concept of route on their drawn cognitive map representations and no other concepts at the projective two stage. If these children had not identified the concept of route at the projective two stage, they would have been placed at the projective one stage of development. Relating to the concept of perspective, some of the children who were placed within the overlapping projective one/two stage identified every concept contained within the projective one stage of development, apart from the concept of perspective. The absence of this one concept stopped them from being placed in the projective two stage of development, because they had depicted other concepts within this stage. The results of testing carried out justified modifications to the checklist. Although the problem of over-lapping still existed it was at a lower percentage.

The second problem was concerned with a high percentage of children who were producing drawn cognitive map representations which were assigned different stages of development between Map Areas A (the school and its perimeter) and Map area B (a different but familiar area approximately two/three miles away from the school). Yet an important criterion in the development of the instrument was the consideration of using two different but familiar areas. This observation indicated a possible conflict between children's drawn cognitive map representations and the Piagetian perspective that implied children pass from one stage of development to the next and that the order of the stages is constant and sequential. Although Piaget suggested that each stage is necessary for the following one, in 1971 he also argued that an important problem for the theory of stages is that of time lags. At certain stages the child is able to solve problems in quite specific areas, yet if one changes to another material or to another situation, even with a problem which seems to be closely related, lags of several months are noted, and in some cases even of one or two years. It was important to resolve this problem prior to the presentation of the results as only one stage of development for each child would be required as the dependent variable for some of the statistical testing. Therefore, for the purpose of this research the Piagetian perspective that children progress from stage to stage was accepted and a decision was taken to use the higher stage of development achieved by the children on either their drawn cognitive map representation relating to Map area A or B. For example, if a child understood the concept of route (1) at the topological stage for both Map areas A and B, the child was placed at the topological stage. However, if a child understood the concept of route (2) at the projective one stage for Map area A but not Map area B then the higher stage of development achieved would be accepted and the child placed at the projective one stage.

Chapter Four is concerned with the presentation and analysis of the results relating to each of the seven separate and the 'overall general mapping ability' variables. The results relating to the stage of development variable showed that although the majority of children were placed at the projective one stage of development, the spread of stages was more complex than either Piaget's (1955; 1960) three stages or Catling's (1978) four stages of development. The problem of the over-lapping of stages has produced eight different stages of development or developmental categories.

The six variables producing quantitative measures highlighted a vast number of diverse outcomes. For example, children gave more responses relating to Map Area B than Map Area A when considering the cartographic concepts, directional and environmental perception variables. But when considering the cartographic features, large scale Ordnance Survey map and vertical aerial photograph variables the children gave more responses relating to Map Area A than Map Area B. One of the interesting results was that children found it easier to interpret features depicted on vertical aerial photographs than features depicted on large-scale Ordnance Survey maps, possibly because vertical aerial photographs are depicted in iconic form, whereas Ordnance survey maps are depicted in plan form.

The total number of responses from each of the separate variables were combined to form a total score relating to the 'overall general mapping ability' variable and the results of testing for significance showed that more responses were given for Map Area B than Map Area A. By combining the mean scores for both map areas and comparing these scores with stages of development (or developmental categories) and year groups, two similar developmental patterns emerged. For example, the mean score at the emergent stage of development (developmental category 1) was 26.59 and at the reception year group the mean score was 29.13. At the Euclidean stage of development (developmental category 8) the mean score was 114.00 and at Year group 6 the mean score was 96.92. The results of a two factor analysis of variance (stages of development x year groups) relating to the 'overall general mapping ability' variable, indicated that there are main effects between some (but not all) of the stages of development and 'overall mapping ability' scores, and between most (apart from between Year groups 4 and 5) of the year groups and 'overall mapping ability' scores. However, there are no main effects for the stages of development x year group interaction and this suggests that stages of development (developmental categories) and year groups, although inter-related are not compatible. In reality it is difficult to match the eight stages of development (developmental categories) with the seven-year groups (comprising 36 children in each group) because the majority of the children were placed at the projective one stage of development.

Chapter Five is concerned with drawing together the findings of the research and to determine if the research questions were answered. The research questions were "Can a method be developed to measure children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" In addition, "Should an emergent stage be included to accommodate children who could not be placed into a stage of development. Finally, because there is still speculation concerning gender, the question "Are there gender differences overall general mapping ability?" was also considered.

The present research has answered the main questions and shown that it was possible to develop a method as a means of measuring children's 'overall general mapping ability', which could be used across the primary age range with a variety of pupils at different stages of development. An emergent stage of development should be included as the result of the testing showed that 7% of the sample was placed at this stage. Children were placed at this stage because they were unable to depict an understanding of route on their drawn cognitive map representations. Had they done so, they would have been placed at the topological stage of development. However, they did have the ability to respond in the other variables contained within the umbrella term of 'overall general mapping ability'. For example, they attained the following mean scores for: cartographic features (9.24), direction (5.98), vertical aerial photographs (5.94) environmental perception (3.71), large scale Ordnance Survey maps (2.41). Although there is still speculation concerning gender, these results showed that there were no statistically significant gender differences.

This is an area greatly in need of research, as explicit and objective techniques of monitoring the interpretation of cognitive map representations (both drawn and verbal) are required. Wickstead's (1991) raised questions concerning the subjectivity of attempting to use Catling's (1978) illustrated table for interpreting children's drawn cognitive map representations into stages of development. The present research has shown that by changing Catling's comments into 'Yes/No' questions and answers, using the definitions of general mapping terms by (Catling, 1978 & 1981; Bale, 1987; Mills et al, 1988; Harrison and Harrison, 1989; Boardman, 1990; Weigand, 1993; Marsden and Hughes, 1994), the subjectivity could be removed.

Future research could use this present research as a starting point and construct an acceptable and manageable instrument to be used by teachers in their classrooms. However, in hindsight, if the instructions to the children (told in the form of a story) were altered to include the two different familiar map areas in the one story, this would involve the construction of one instead of two drawn cognitive map representation by the children. By adopting this procedure it is speculated that the time spent on testing by teachers in their classrooms could be reduced by approximately 50%, as only one checklist relating to Map area A and B for each of the variables would be required. It is hypothesised that the results of any future testing would be consistent with the results of this present research relating to the 'overall general mapping ability' variable.

CHAPTER 1

THE LITERATURE REVIEW

Introduction

This research sets out to explore the possibility of using primary school children's cognitive map representations as a measure of their general mapping ability. Before considering the literature in this field it is important to define the main terms that are used in this work. Researchers such as Catling (1978,1983), and Boardman (1990), agree that children's cognitive map representations are the external products of children recalling and reconstructing internal processes of their experiences of places which are familiar to them. Hart and Moore (1973) suggest that these external products include drawings, published maps, vertical aerial photographs, verbal reports, and models. The construction of models can be used either as an alternative technique or reinforcement to the drawn cognitive map representation. Verbal responses are important because some children are able to describe in more detail what they have depicted on the drawn cognitive map representations, especially when they attempt to describe a route in directional terms. Movement in the large-scale environment such as wayfinding (Martland 1994, Ottosson 1987 and Blades and Spencer 1987) is another example of these external products.

A drawn cognitive map representation is an attempt by an individual to represent a map held in their mind, which is based upon the recall and reconstruction of experience. It may be represented as a sketch on paper, sand, soil or other surface so as to portray an individual's subjective personal views of the world or some portion of it; and is a reflection of the form of a particular geographical area (Stolman 1980 p3). Figure 1.1 shows an example of an eight-year-old boy's drawn cognitive map representation of the school he attends and its perimeter. Although it does not resemble a section of a large-scale Ordnance Survey map showing the same area (Figure 1.2), it does contain the same cartographic elements of a building and paths. However, on the drawn cognitive representation these elements are depicted in an iconic form, whereas on the Ordnance Survey map the features are depicted in plan form.

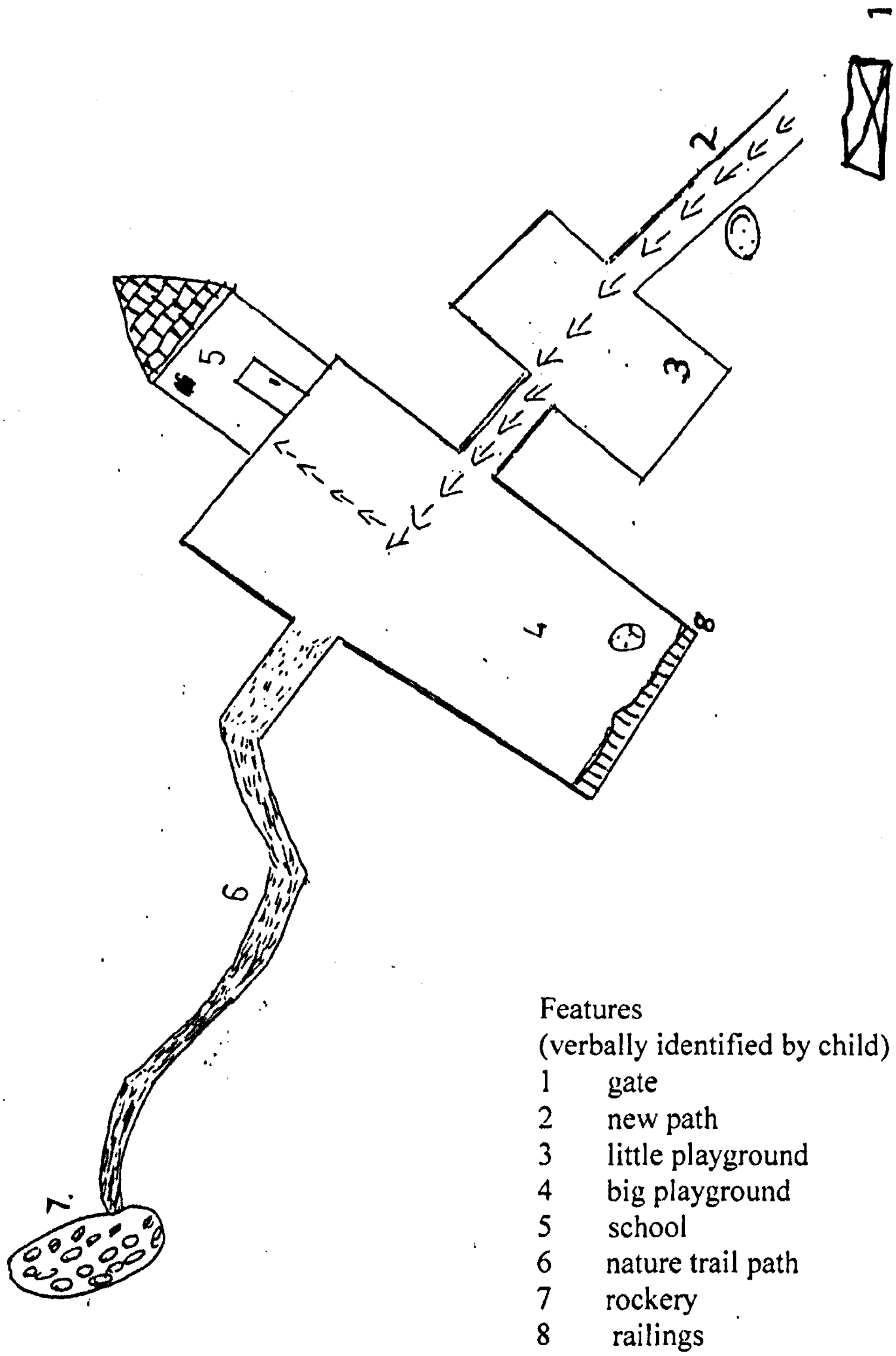


Figure 1.1 A drawn cognitive map representation, by Brian (age 8 years)

<u>KEY</u>

A School field
B Infant playground
C Junior playground
D Nature trail

Figure 1.2 A section of a 1:1250 Ordnance Survey map

The definition of a map is that it is both a locational document and a scaled down representation of reality. In this sense maps are models usually drawn on flat sheets of paper, although this is not necessarily so. For example, Weigand's (1998) research was concerned with children drawing a map of the world on a football sprayed with blue paint. In Piaget et al's (1960) research, children positioned models of buildings, roads and other features on a sandtray.

The main elements of a map are perspective, symbols, location, direction, scale and distance (Weigand 1993). Catling (1981) and Mills et al. (1988) suggest that maps serve four functions: -

1. A map is a locational document showing where a place is in relation to other places.
2. A map is a route-displaying document. It gives an opportunity to show a route from A to B.
3. A map shows/suggests what a place or an area may look like.
4. A map is a useful way of storing and displaying information.

Map making is a subjective process and varies in content depending on its purpose. The cartographer has to decide what features of the real world to include and what to omit (Weigand 1993). Figure 1.2 shows an example of a section of a published Ordnance Survey map (showing features depicted in plan form) at a scale of 1:1250. Although most published maps are depicted in plan form, some maps such as the "You are here" theme maps and weather forecast maps show features depicted pictorially. Although most maps show how features are geographically related to one another and where they are located, other maps, such as rail and train station maps are related to distance or time, only showing rail lines and station names (Mills et al 1988). Because of the variations within map making, there appears to be little difference between drawn cognitive map representations and published maps, apart from the fact that some drawn cognitive map representations may need supporting explanations of what was drawn by the primary school children. Perhaps the difference is in the use of acceptable conventions both of representations and the selections for inclusion and exclusion. As such they tend to be representations of the societal and adult view of what is important.

THE LITERATURE REVIEW

Cognitive Map Representations

The literature review addresses a number of interrelated different areas, namely: cognitive map representations, developing stages of cognitive map representation, general mapping and general mapping ability. Cognitive map representation is addressed first, because the main question to be addressed in this research is "Can primary school children's cognitive map representations be interpreted and used as a measure of their general mapping ability?" There has been a good deal of research into the use of cognitive map representations relating to mapping ability, but not all researchers in the field use the same terminology. It is important to recognise the wide range of alternative terms used to define and describe these representations. Table 1.1 shows examples of alternatives to the term 'cognitive map representation' and Table 1.2 shows examples of alternatives to the term 'cognitive' maps and 'cognitive mapping'. Each of the researchers use these terms in particular and slightly different ways as we struggle to find the best language to describe these abstract concepts

Table 1.1 Alternatives to the term of cognitive map representation

	RESEARCHER
external or topological representation	Hart and Moore 1973
cognitive mapping or spatial representation	Catling 1978/1980
mental map	Stoltman 1980
free recall maps	Matthews 1984
free recall sketch maps	Weigand 1998

Table 1.2 Alternatives to the terms of cognitive mapping and cognitive maps

	RESEARCHER
topological schema	Piaget et al 1960
spatial concept	Piaget 1969
spatial cognition or internal representation	Hart and Moore 1973
schema or mental model	Pocock and Hudson 1978
internal processes of experience of familiar places	Boardman 1990

For the purpose of this research the terms 'cognitive mapping', 'cognitive maps' and 'cognitive map representations' will be used. Cognitive mapping is the process of collecting thoughts and knowledge of the environment. A cognitive map is retrieving some of these thoughts and knowledge to answer questions relating to a particular environmental task at one moment in time. The cognitive map representation is the external product of cognitive mapping and cognitive maps. The processes underlying these terms are relevant to both adults and children and the main differences between the terms are outlined as follows: -

Cognitive mapping

Downs and Stea define cognitive mapping as:

> a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena of his everyday spatial environment
>
> (Downs and Stea, 1973a, p.9)

This definition suggests that cognitive mapping is a mental process concerned with the continual collection and re-organisation of objective knowledge and subjective thoughts, relating to the external geographical environment.

Cognitive maps

A cognitive map is the processing of the cognitive mapping information stored in the memory for one particular task at one moment in time. Only the information required is extracted, and this process is a cognitive map. Downs and Stea (1973 p10) suggest that a cognitive map is a coping mechanism through which the individual answers two basic questions quickly and efficiently. The questions deal with, where certain valued things are, and how to get from one particular place to another. This is reiterated by Siegal (1982) who suggested that:

> The process of cognitve mapping is only in part cognitive: Children overlay social learning on their cognitive maps. They learn where different behaviour settings are and, in doing so, learn where to go to find things, people, personal involvements or assistance.
>
> (Siegel, 1982, p.88)

this quote suggests that cognitive maps are concerned with both the cognitive and affective domains.

The difference between the terms 'cognitive mapping' and 'cognitive maps' is that cognitive mapping describes the process that happens first. They are both internal mental processes concerned with the cognitive and affective domain and play an important part immediately prior to a cognitive map representation being produced. Although the word 'map' is used in these two respects, Matthews (1992 p98) suggested that this term, "is no more than a metaphor"

Cognitive map representations

Although the word 'map', "is no more than a metaphor" when considering the definitions of cognitive mapping and a cognitive map, it needs to be clarified that a 'cognitive map representation' is a 'map' when it is externally represented. Researchers such as Catling (1978,1983), and Boardman (1990), agree that children's cognitive map representations are the external products of children recalling and reconstructing internal processes of their experiences of places which are familiar to them. Hart and Moore (1973) define the term 'external representations' (meaning the same as cognitive map representations) as including drawings, published maps, vertical aerial photographs, verbal reports, and models. Martland (1994), Ottosson (1987) and Blades and Spencer (1987) include movement in the large-scale environment. These external representations have been used as techniques by different researchers in order to elicit the internal processes of children's experience of place and will be discussed later in this chapter. But it is important to acknowledge that there are differences in how spatial knowledge is internally processed by children. Matthews (1992) stated that although there are competing theories, there is an overall agreement of progression from landmark to route to configurational knowledge. At the same time, there is also an agreement of progression from topological to projective to Euclidean properties. Three examples of these theories are outlined below:

The Piagetian Theory

Blades (1997) acknowledged that Piaget, Inhelder and Szeminska (1960) put forward the first theoretical description of how children develop an understanding of the environments in which they live. They emphasized the importance that understanding a route requires an understanding of the spatial relationships between places along a route. For example, for children to find their way along a route they need to form a representaion of that route. Piaget implied that young children learn routes before they understand the relationships between landmarks along the route.

Piaget's stages of intellectual development can be applied to cognitive map representations as well as to other aspects of learning. He concluded that all children pass through a series of intellectual developmental stages. The first stage in their thoughts are described as pre-operational which usually occurs between the ages of four and seven years when children can only grasp one relationship at a time. For example, if they are working out a problem, they have to carry it out, from start to finish or abandon it; they cannot work half through it and then think back to the beginning of the problem at a later point. The concrete operational stage usually occurs between the ages of seven to eleven years when logical thought is being developed. Children at this stage have not yet reached the abstract stage of intellectual development and their thought is being developed through practical activities. The formal stage occurs from the age of eleven years when there is less need for concrete material and children can hypothesize and have the ability to think in abstract terms. Although his theory of intellectual development is fundamental to every aspect of child development, Piaget and Inhelder 1956; Piaget et al's. 1960 theory of Euclidean spatial development is particularly relevant to the developing stages of children's cognitive map representations.

Piaget's findings suggested that there are three stages of development in the construction of Euclidean space, beginning with a simple topological type of relationship and following a gradual transition through to the projective and finally the Euclidean stage (Piaget and Inhelder, 1956; Piaget et al. 1960). A more detailed explanation follows: -

THE TOPOLOGICAL STAGE

Piaget et al's. (1956; 1960) argument is supported by Catling (1978) and (Weigand 1993), in suggesting that, at this stage, children are highly egocentric and their cognitive map representations show features drawn iconically and not in plan form. Any features included are those pertinent to the experience of the children and those without meaning to them are ignored. Routes drawn on the maps of children at this stage are shown leading away from familiar places or objects, and the terms 'to the left' or 'to the right' only refer to objects or routes from their own ego-centric point of view. At this stage, cartographic concepts, such as direction, orientation, distance and scale are non-existent.

THE PROJECTIVE STAGE

Projective relations are geometrically more complex than topological relations, and by the age of seven years, children have usually reached a stage of development in which their topological representation of the world becomes 'projective'. They can begin to imagine a route in their minds and recreate it on a piece of paper so that rights and lefts appear with reasonable accuracy. The understanding of the concepts of angles and area is beginning to emerge. Piaget refers to this as the 'projective stage' in children's development because children are able to project themselves into another viewpoint. At this stage, features drawn on maps are usually placed in the correct sequence but not at correct distances. Children are now learning to decentre themselves, think in abstract terms and involve their minds in a number of different viewpoints. This is the main and most important difference between the projective stage and the topological stage. However, at the same time, children are also beginning to use some Euclidean concepts, such as measures of length, area and angles. Their drawn cognitive map representations are likely to show some disconnected routes or areas (Piaget et al 1956; 1960, Beard 1969, Barker 1974, Weigand 1993).

THE EUCLIDEAN STAGE

The Euclidean Stage comes when children have progressed from the 'ego-centric' to the 'abstract' stage, and this usually occurs at about the ages of ten and eleven years of age. This is when the concepts of a map as an accurate, scaled representation of the environment is acquired. It is at this stage that the relationship of objects in space are structured in the mind as though they were placed on a grid of horizontal and vertical lines and each object is placed more or less in its correct vertical and horizontal position relative to the other objects. The concepts of direction, orientation, distance, shape, size and scale are all roughly accurate and because symbols are no longer depicted iconically, a key is required (Piaget et al. 1956; 1960, Catling 1978, Gerber 1981a and b, Weigand 1993).

Siegel and White's 'Mini-map' Theory

The second example of a theory is put forward by Siegel (1981) who argues that in Siegel and White's (1975) theory, landmarks and routes are the predominant elements of cognitive maps and in contrast to Piaget's route theory, landmarks are the first to be noticed and remembered. While acting in the context of these landmarks, routes linking them are formed. Finally, routes are integrated within an overall framework as configurations or survey maps. The general hypothesis is that a route is a linear representation of some piece of the large-scale environment; it is temporally and spatially integrated and constructed and organized around landmarks. In Siegel and Whites (1975) hierarchical model, routes are both super-ordinate to landmarks and super-ordinate to configurations. They proposed a sequence of development and environmental knowledge, which includes knowledge of landmarks, routes, mini-maps and survey knowledge. Their first stage of children's environmental learning is noticing and remembering landmarks. In the second stage children can use landmarks as reference points for their behaviour in the environment. For example, the decisions and actions which a child carries out at a particular landmark, such 'turn left', becomes associated with that landmark and the sequence of landmarks provide a basis for an associated sequence of decisions so that a child is able to follow a complete route. According to Kitchen and Blades (2001) this is followed by a third stage in which children can form clusters of landmarks which Siegel and White (1975) label as 'mini-maps' With greater experience such 'mini-maps' become integrated into a larger framework and children will then have achieved a 'survey' representations of the environment. This is the fourth stage of learning, when the relationships between all landmarks and places in the environment are understood.

Golledge's 'Anchor-point' Theory

The third example of a theory is put forward by Golledge and includes elements of both Piaget's 'route' and Siegel and Whites 'mini-maps' theories. Golledge et al (1985) and Golledge (1999) proposed an 'anchor point' theory in which locations, features, path segments, or familiar districts 'anchor' cognitive maps. The basis for his theory was the assumption that route information could be organized as a series of subdivisions surrounded by distinct environmental features (similar to Siegel and White's 'mini-map theory), rather than being organized strictly as a sequence of landmarks connected by pathways (similar to Piaget's route theory).

Golledge (1999) suggested that landmarks act as anchor points for organising other spatial information into a layout and for humans the most pervasive anchor is the home base. An integral part of route knowledge, survey knowledge, and the transition between them is a hierarchical ordering of place that comes about through a system anchored by primary, secondary and tertiary nodes and the paths that link them. Primary nodes are those places, which are first understood, and these relate to the child's home and to other familiar environments. Primary nodes serve as anchor points from which the rest of the hierarchy develops and as interaction takes place along the paths between primary nodes there is a 'spillover effect', in the course of which other places around the primary nodes become known. In turn these additional places become secondary nodes and in this sequential manner, tertiary nodes become fixed to the system. Golledge tested this model in relation to how a single 11-year boy learnt a novel route, over a five-day period, by completing one forward and one reverse navigation trial. The results indicated that knowledge of a route is focused on key choice points; choice points serve to segment a route. With experience, these segments become increasingly differentiated and appropriately sequenced; routes appear to be hierarchically organized, both with respect to choice points and the segments, which they anchor. For example, knowledge of route cues and features is concentrated at areas where real or potential actions occur. These areas can be further differentiated into four types: (1) a choice point where a change in direction and a street crossing occurs, (2) a choice point where only a change in direction occurs, such as turning a corner; (3) a choice point where a significant action occurs but there is no change in direction such as crossing a street but continuing straight ahead; and (4) an area where a choice does not occur, that is an area along a route segment between two choice points.

The three examples of theories discussed above were concerned with the internal processes of children's experiences of places, which are familiar to them. However, cognitive map representations are the external products of these internal processes. The drawn cognitive map representation is an example of one of several types of techniques used by researchers in order to elicit the internal processes of children's experience of place.

The drawn cognitive map representation

Kitchen and Blades (2001) suggest that 'sketch mapping' (meaning the same as the term 'drawn cognitive map representations') has been a frequently used technique to gather information about configurational knowledge. They outline four different types of 'sketch mapping' relating to techniques used by researchers:

The basic sketch map technique depends on eliciting a freely drawn sketch map that has been minimally defined by the researcher. A participant is given a blank piece of paper and asked to draw a map of a given environment, with a general instruction such as 'Draw a map of London', but without any instructions about what should be included. (Kitchen and Blades 2001). Liben (1997) used a basic map technique as part of Liben and Downs (1986) research involving five to eleven year old children. The children were asked to draw maps of their classroom and of their school. There were few constraints on children, either with respect to their experience in the place or with respect to the precise form of their representation (although the pencil and pen medium was fixed). Liben and Down's research is discussed later in this chapter.

The normal sketch map technique

Kitchen and Blades (2001) suggests that the normal sketch map technique imposes more constraints than the basic approach. The researcher is often interested in more specific features and will word the instructions appropriately to obtain the required data, for example. “Draw a map of London. Include and label any districts you think you know the location of”. This method gives the researcher some control over the type of sketch maps produced. Matthews (1985a) used the normal sketch map technique as part of his research involving children aged between six and eleven years from four different schools. The children from one of the schools were asked to draw two different maps and were given the following instructions: -

> Imagine that you were taking me with you on your journey from your home to this school. Please would you draw me a map of the way we would go, showing me things that we would pass on the way. Name any of these features that come to mind.
>
> and
>
> Imagine I was staying at your home and you were going to show me the area around your home. Please would you draw me a map of the area around your home, showing me some of the things I might see nearby. Name any of these features that come to mind.
>
> (Matthews, 1985a, p.264).

Matthews’ instructions were given in order to elicit as much cartographic information as possible, because what is shown on drawn cognitive map representations is pre-determined by what was asked of the children in the first place. Matthews (1984a) argued that because children learn about different environments in different ways, two environments were used, “so as to provide the potential for the full richness of environmental images to be called and represented” (Matthews 1984a, p91). He implied that:

> when faced with a linear journey, the route itself becomes a well-remembered construct, but when describing an area, such as around their home, spatial properties loom large in the minds of the young
>
> (Matthews, 1984a, p.93).

The cued sketch map is a technique when the participant is provided with a portion of the map and asked to complete specific features. This use of cued sketch mapping introduces a common scale to the results, but may also influence the results because some of the information is inevitably provided by the researcher (Kitchen and Blades

2001). Golledge (1999) and Joshi et al (1999) both used this technique. Golledge printed a church and a park; and Joshi et al printed a school in the centre of drawn cognitive map representations prior to being completed by the children).

The longitudinal sketch map technique allows the researcher to study how the sketch map evolves, because a participant is asked to sketch the map on layers of tracing paper that can be turned over as the participant continues to draw (Kitchen and Blades 2001). Wood and Beck (1976; 1995) and Beck and Wood (1976), used the longitudinal sketch map technique in their research concerned with the affective imagery of the urban environment and the development of a mapping language in which people could be taught to communicate with researchers using maps. Environmental A was a graphic mapping language designed for use by American teen-age students touring Europe. It contained symbols for three basic kinds of urban elements (points, lines and areas), which when mapped become representations of the urban environment. The symbols and their meanings were contained in a book that the students carried about with them and used when mapping.

Wood and Beck suggested that their 'composite map' consisted of six layers. For the first layer, the students were told to place a dot in the centre of a piece of paper and this dot represented the centre of whatever was being mapped. They were then told to "Visualise the way the streets run off from this point, to travel down them in your mind until you come to a second point and connect these two points with a simple line". They were told to continue in this manner to build up a 'skeleton' map. The students were then given five sheets of tracing paper to be used as overlays. For example, the were asked to outline and label areas on the first overlay; and through the use of symbols the dot in the centre of their 'skeleton' map could now be identified as a building. All points, such as landmarks, would be described on the second overlay; line symbols, such as rivers or roads, would be described on the third overlay. The fourth overlay was used for descriptions of areas, such as industrial or residential, and the fifth overlay was left for the attribute symbols, which enabled the students to express their feelings about any point, line, or area. Wood and Beck concluded that their longitudinal sketch map technique made mapping a full range communication system.

Catling (1978 p121) produced an illustrated table showing examples of four children's drawn cognitive map representations of the same large-scale environment relating to Piaget's stages of development and at the same time depicting some of the conventionally accepted elements of maps. For example, roads and paths, buildings, park, direction, orientation, perspective, distance, scale, shape, size and a key are illustrated (Figure 1.3). Some of these cartographic elements have been depicted in an iconic form, while others have been depicted in a symbolic or plan form. Map styles 1 and 2 show all buildings depicted in an iconic form, while map style 3 shows buildings being depicted in both an iconic and plan form. The more developed map style 4 shows all buildings being depicted in plan form. Other features such as trees, traffic, sandpit, lampposts and even a plane, were also depicted. Some of the features were labelled "a happy school", "Jim's house", and "my house". Catling's four examples show that children include not only cartographic elements relating to the cognitive domain on their drawn cognitive map representations, but also features relating to the affective domain of environmental perception. Lynch (1960) refers to the affective domain of environmental perception as 'imageability' which is the individual's subjective judgment regarding the degree to which features of a particular environment are important. He argues that:

> the image is used to interpret information; to guide action; to serve as a broad frame of reference, within which a person can organise activity, belief, and knowledge; to serve as a basis for individual growth; and to give a sense of emotional security.
>
> (Lynch, 1960, p.8)

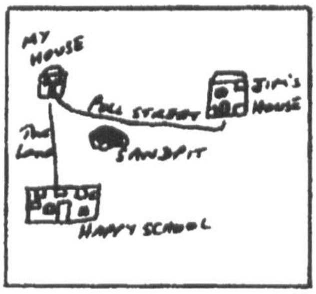
Although Lynch's (1960) research in America was concerned with adults, his methodology is still relevant to primary school children. He asked the cohorts to draw maps of the central area of their city as if they were drawing them to help a stranger. He categorised the content of the maps and concluded that the results could be considered under the five major organisational elements as follows: -.

Paths are the routes, which people take while moving through a settlement, such as footpaths, pavements, roads and trails etc.

Developing Stages of Cognitive map representation

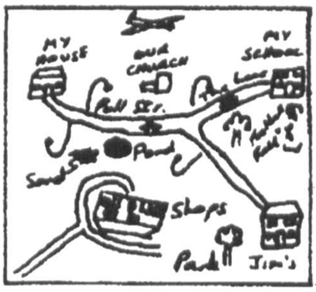
Stage | Map style | Stage and comments

Topological
[Egocentric]



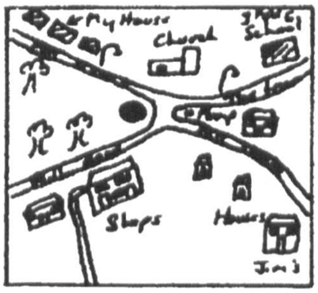
1. Link-picture map
Highly egocentric. Known places connected to home. Solely iconic. Direction, orientation, distance, scale non-existant. Unco-ordinated map.

Projective 1
[Quasi-egocentric]



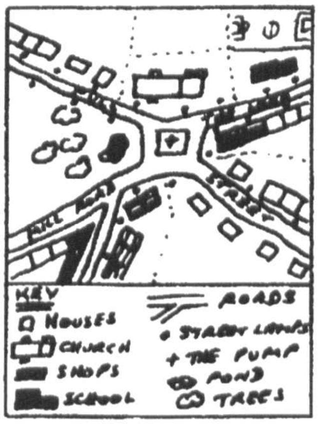
2. Picture map
Still egocentric. Partial co-ordination and connection of known places; direction more accurate. Road in plan form, but buildings iconic. Scale and distance inaccurate. Little development of perspective.

Projective 2
[Quasi-abstract]



3. Quasi-map
More detailed and differentiated. Better co-ordination; continuity of routes. Some buildings in plan form. Direction, orientation, distance and scale improved. Better perspective.

Euclidean
[Abstract]



4. True map
Abstractly co-ordinated and heirarchically integrated map. Accurate and detailed. Direction, orientation, distance, shape, size, scale all roughly accurate. Map in plan form. No symbols highly iconic, so key necessary.

Figure 1.3 Catling's (1978) illustrated overview

Nodes are important points or places in an area that people can enter into and move through. For example, where paths come together (a crossroad or a road junction) or places that people can enter such as a station or church etc.

Landmarks are conspicuous objects or buildings and necessary to show the directions and distances of positions in one space with respect to positions in the other.

Areas or Districts are parts of a settlement into which a person enters. They are recognisable as having some common identifying features. For example, all houses are similar, docks, shopping centres etc. Areas and districts can also be an area with a local name.

Edges are boundaries or barriers between features in a settlement, such as breaks in the continuity of the landscape. Edges embrace, rivers, canals, railway lines, parks, change in housing styles etc.

Although Lynch's five major organisational elements, have been adopted in research relating to drawn cognitive map representations (Matthews 1984a), there are some features depicted by the children on their drawn cognitive map representations such as trees, sand-pit, or lamp-posts (Figure 1.3) that do not fit into any of these elements. Yet these features play an important role in the affective domain of children's drawn cognitive map representations. Hart (1979) addressed this problem by devising four major categories to organise the results from his research. His research was concerned with attempting to find out what the children liked, disliked, feared, and found dangerous about different places in and around the children's home area. Hart's four major categories are:

Land-use places valued because of the use children put them to in their play. For example, the playing field in the town centre, rivers and lakes, and child-built places such as dens etc.

Commercial places valued because of what can be bought or otherwise obtained there. For example shops and ice cream stands.

Social places valued because some individual lives or works there or because some particular social event occurs there. For example, school friends' homes, adults' homes, and parent's place of work, another school, Brownies, Scouts etc.

Aesthetic places valued because of what they look or feel like. For example, empty buildings, attics, cellars and child's own bedroom at night, dangerous animals of the woods.

Hart's categories have offered an alternative to Lynch's method of categorising the contents of children's drawn cognitive map representations. Lynch's method is more explicit, but does not allow for features such as trees to be categorised. On the other hand, Hart's method allows for the categorising of features such as ice cream stands, but this method may be too ambiguous and subjective. For example, Hart placed the ice cream stand in the commercial categories, but equally it could have been placed in the social or the aesthetic category. The contents of the drawn cognitive map representations can be categorised by using either Lynch's or Hart's methods. But, there is always the possibility that children may know far more about their spatial environment than they are able to draw on paper (Boardman 1990 p59). The next section explores the extent to which the literature provides information as to what is known, but not shown, on drawn cognitive map representations.

Verbal directional language

In order to elicit as much spatial information as possible, there is a need for children to talk about their drawn cognitive map representations through one-to-one, researcher and child discussions. For example, children may possess far more directional language than an arrow (or line) depicted on a drawn cognitive map representation. Harrison and Harrison (1989) suggested that pupils already possess a sense of direction, which they bring to school with them. They use their own shorthand for giving and receiving directions, for example: -

> "past the shops and over the park". Some pupils understand direction but have great difficulty in expressing themselves.... there is a vital need to provide opportunities for children to verbalise their thought and to practise giving and hearing directional language.
>
> (Harrison and Harrison, 1989, p.20)

Children may possess the ability to give verbal directions of a route, whether or not they have drawn the route on their drawn cognitive map representations. They may also know far more about direction than a drawn line or a row of arrows between two points. This is not shown on their drawn cognitive map representations, yet this knowledge is known and an important element of children's cognitive map representations.

Environmental perception

Environmental perception is another element in the cognitive map representation process, because it is concerned not only with "What is there?" and "Why it is there?" but because it also gives an insight into the way children feel about and value the places in which they live out their daily lives (Siegel 1982). Place can be real or imagined. Attributes of places can be objective or subjective, where one person perceives an undistinguishable terrace house, another sees a monument to the birthplace of a famous person. Some places are identified by a feeling (such as fear) rather than by objective features (Golledge 1999).

In order to elicit this affective element of information relating to drawn cognitive map representations, one to one discussions between researcher and child should take place. There is a need for children to verbalise about what they have drawn on their cognitive map representations. In some instances, the children will have drawn features, but need the opportunity to explain their feelings about what they have drawn. In other instances, children may not have included certain features, but they know that these features play an important part in their daily lives. For example, a child may have drawn a house with curtains on the windows on the drawn cognitive map representation. On being questioned, it was found that the child was scared and did not like going past the house because a dog would bark loudly through the windows. Scoffham (1998 p27) suggested that what a place is like is not simply a matter of fact. It equally depends on how we perceive it and what we feel about it. Lynch (1960) emphasized that imageability is an important aspect of the affective domain of cognitive map representation, and Geography in the National Curriculum (England) (1991 p33) indicated the importance of children aged between five and seven years being taught to discuss and explain their likes and dislikes about features of their environment.

Other Techniques

Both verbal directional language and environmental perception are implicit parts of the drawn cognitive map representation concerned with the verbal response element of cognitive map representations. But there are other elements of cognitive map representations namely, models, maps and aerial photographs of the same geographical area as the drawn cognitive map representation that may be considered when attempting to measure the general mapping ability of primary school children. Additional techniques include direct experience through movement (or wayfinding) in the large-scale environment.

Models

Piaget and Inhelder (1956) used the model and drawn map method. They studied the way children between the ages of 4 and 10 describe a familiar walk. The research was designed to find out the extent of the children's local knowledge and sense of direction: -

> Each child is taken to the school window where he is asked to point out various buildings and well-known places. This is to find out the extent of his local knowledge and sense of direction. He is then given a sand-tray, wooden houses representing the school and nearby buildings, little pieces of wood representing greens, recreation grounds, public squares and bridges, and a ribbon to represent the River Arve. The experimenter placed the biggest house and puts it in the middle of the sand tray, saying: "Now this is the big school (meaning the primary school as against the kindergarten). There are plenty more houses, little ones and big ones. These little bits of wood are to make bridges with and this blue ribbon is the Arve. Now I want to know about everything near the school. You put the things in the right places." At the end of the first part of the experiment the subject is asked to draw a plan in the sand or on a piece of paper.
>
> (Piaget and Inhelder, 1956, p.5)

Hart (1979) was interested in how children represented the spatial arrangements of places in their everyday home environment. He used models instead of drawings because of the wide variation in motor skill and graphic ability of young children, and because "pencil or pen bring in a degree of commitment to each element drawn which is unsuited to the creative act of constructing a map". Hart used a method similar to Piaget and Inhelder (1956) model method, using ribbon for rivers, wooden houses and a sand tray. The differences between the two methods, were that:

a. Hart used a large piece of paper instead of a sand tray as a base for the model making. In Hart's research, the children were given an 8ft x 8ft sheet of paper as well as models of roads, houses and other cartographic objects. In addition, if the children asked, they were given models of trees, cars, modelling clay and crayons that were used to supplement their models/maps with details.

b. Hart traced around the models on the sheets of paper and he wrote alongside them the names of the places given by the child, whereas Piaget used the model method as a starting point for eliciting children's spatial knowledge.

Wickstead's (1991) research used the model representation as one of several techniques concerned with extensive teaching sessions to an experimental group of primary school children. One of the aspects of importance was the determination through intensive teaching sessions of general mapping concepts and skills to improve their mapping development. The group was divided into the seven primary age groups and each group given a copy of the enlarged Ordnance Survey map and large Lego blocks. They were asked to make a model of the school. No help was given unless it was requested. As mentioned earlier, although it is one of the elements of cognitive map representations it can be used as an alternative method to the drawn cognitive map representation.

Large scale Ordnance Survey maps and vertical aerial photographs

Researchers such as Catling (1978,1983), and Boardman (1990), agree that children's cognitive map representations are the external products of children recalling and reconstructing internal processes of their experiences of places which are familiar to them. Hart and Moore (1973) define the term 'external representations' (meaning the same as cognitive map representations) as including drawings, published maps, vertical aerial photographs, verbal reports, and models. In some respects large scale Ordnance Survey maps and vertical aerial photographs are alike. The most obvious differences between the two are that a large scale Ordnance Survey map has names on it, is depicted in plan form, and only records selective information. The aerial photograph includes everything on the ground, it shows the location of features, but it is iconic and not in plan form.

Part of Matthews' (1984b and 1985a) research involved the use of vertical aerial photographs and large scale Ordnance Survey maps, when testing children between the ages of six and eleven years of age. As mentioned earlier, the tests involved two different familiar areas and all children were given the same instructions. Children from one school were given A4 sized sheets of tracing paper placed over a vertical aerial photograph and asked to trace a map showing the route from, a) their home to school and b) the area around their home. This exercise was replicated using children from a different school who were given A4 sized sheets of tracing paper placed over a large scale Ordnance Survey map. However, in order that "the verbal prompts should not influence the children's images - all written description was erased from the plans, allowing verbalisation to come from the child" (Matthews, 1984b, p.35)".

Cross-cultural research concerned with vertical aerial photographs was undertaken over several years in the late 1960's and early 1970's by Blaut and Stea (Blaut et al 1970; Stea and Blaut 1973; and Blaut and Stea 1971) involving over 500 children (aged three to eleven years of age) in Massachusetts, Puerto Rico and St.Vincent. One of the tests was to find out if children of school entering age could interpret and use a map without training or prior exposure to the representation by using a vertical aerial photograph as a map surrogate map. A vertical aerial photograph was shown to the children, who were asked, "What do you see in this picture? Tell me everything you can see in this picture?" When the child responded with the name of a feature - the experimenter said, "Point to it". The testing continued with children tracing over the vertical aerial photograph and when this task had been completed vertical aerial photograph was removed and the children interpreted their tracing.

More recently, Blades et al (1998) carried out a cross-cultural study involving four-year-old children. The purpose of the research was to discover whether these children could read a vertical aerial photograph and perform a simulated navigation task on it. The initial procedure was similar to the above research, until the children no longer mention and point to new features on the vertical aerial photograph. The researcher then said, "Let's play a game. Let's pretend that this is where you live and this is where your friend lives" (pointing to two houses). The child was then given the following instructions, "Suppose you wanted to visit your friend, can you show me by drawing with your pen how you would go from where you live?" In the Evanston study children were randomly assigned to two testing groups. One group navigated with a tiny toy bird; those in the other group, with a tiny toy car. Children in the 'bird' group were asked to show how the bird would go from one house to the other. Children in the 'car' group were asked how the car would go from one house to the other.

Movement in the large-scale environment

Although movement in the large-scale environment is an alternative example of an external product of cognitive map representation, it was not used in this research. The reason it was not included was because one of the objectives was to construct a standardised test to be used by teachers in their classrooms as a means of measuring primary school children's overall general mapping ability. Although the primary objective was concerned with the 'product' it should be emphasized that the 'process is equally important'. As Weigand argues that:

> There seems to be no substitute in the process of learning new areas to that of actually getting out there and finding your way... Recently the suggestion has been that wayfinding and orientation ability are innate skills rather than skills acquired by formal education.
> (Weigand, 1993, p.151)

Blades and Spencer's (1987) research involved 120 children (4-6 year olds). The research was to determine if young children could use a map to follow a maze. A large maze was constructed on a playground floor. The children were told that they could only walk along the paths and after doing so; they were shown a map of the maze. They were then asked to use their fingers to follow the correct route on the map. The results showed that many young children could understand simple maps often a number of years before experience of any formal map-work in schools.

A similar wayfinding technique was undertaken by Bremner and Andreason (1998) whose research was concerned with young children's ability to use maps and models to find ways in novel spaces. The testing involved 40 primary school children divided into two age groups with. A task involving a maze layout was carried out to investigate the effect of map-space alignment on performance of young children (mean ages of 4.9 and 5.3 years). Each child was tested individually and prior to the testing the children were led to the start of the maze and it was pointed out that the white tapes marked the permissible paths through it. They were led through the paths and shown where the toy animal was hidden at each barrier. The children's task was to get through the maze collecting as many toy animals as possible but without correcting wrong turns. A map was shown to the children and it was explained to them, how it could help them to find the toy animals. The child was then asked to use the 'picture' to lead the experimenter through the maze finding the toy animals. The results showed that children in both age groups used the map accurately to navigate the route up to the turn, although the presence of a bend in the maze increased the difficulty of the task.

Martland's (1994) research involved 400 children aged between seven and eleven year old. It was concerned with creating a teaching programme of mapping skills and draws heavily on firsthand experience and discovery. And that orientation of the map and the ability to update ones location on the map as a route is followed are key mapping skills. The results showed that seven-year-old children could orientate maps with the aid of a compass.

The above review of literature has addressed the different elements of cognitive map representations and the procedures and use of techniques carried out by different researchers in order to elicit this information. The following parts to this chapter address the results of the research concerned with cognitive map representations and attempt to relate it to general mapping ability of primary school children.

THE LITERATURE REVIEW

General mapping ability

Introduction

The previous section addressed the elements of cognitive map representations and the procedures carried out by different researchers in order to elicit children's mapping ability. This section addresses literature concerned with results of the research to attempt to relate it to the general mapping ability of primary school children. Collectively, any mapping concepts, skills and features identified by primary school children (either drawn or verbal) through their cognitive map representations can be termed as 'general mapping'. Therefore, for the purpose of this research, 'general mapping' is an umbrella term and embraces the elements of cognitive map representations addressed in the previous section, apart from the element of model making. These elements will now be referred to as variables of general mapping ability and they are as follows:

Drawn cognitive map representations

Stages of development

Cartographic concepts

Cartographic features

Verbal cognitive map representations

Verbal directional responses

Verbal environmental perception responses

Ordnance Survey map interpretation

Aerial photograph interpretation

For the purpose of this research, two theories of measuring primary school children's general mapping ability have been identified. Both of these theories are relevant when considering the question, 'Can children's cognitive map representations be used as a measure of their general mapping ability?' The qualitative approach has been addressed by theorists such as Piaget et al. (1960), Ladd (1970), Appleyard (1970), Hart and Moore (1973), Catling (1978) and Ottosson (1987) showing how groups of children can be placed into stages of development. The quantitative approach has been addressed by theorists such as Lynch (1960), Hart (1979), Matthews (1985a), Blades and Spencer (1987), Weigand (1998) and Harwood and Usher (1999) showing how a quantitative score can be given to individual children.

Measured through stages of development

The current study reported in this research (working within a Piagetian paradigm) examines the possibility of using primary school children's cognitive map representations (drawn and verbal) as a measure of their overall general mapping ability. Placing children's drawn cognitive map representations into developmental stages is concerned with qualitative changes, and this section addresses the literature of Piaget et al. (1960), Ladd (1970), Moore (1974), Appleyard (1973) and Catling (1978) in order to identify some common elements relating to development in children's drawn cognitive map representations.

Piaget's theory of stages of intellectual development and Piaget's (1956; 1960) theory of Euclidean spatial development has already been discussed in the previous section of this chapter. The three stages of development in the construction of Euclidean Space, in theory, should be sufficient to use as a model for interpreting children's drawn cognitive map representations and placing them into developmental stages. But Piaget has highlighted some ambiguities that may hinder the interpretations. These ambiguities were not a major issue to Piaget because as Beard (1969, p.70) argued, Piaget was not concerned with quantitative results but how groups of children pass from one stage of development to the next. On the one hand, Piaget points out that the order of the stages is constant and sequential; on the other hand, Piaget's (1971) argues that an important problem for the theory of stages is that of time lags. At certain stages the child is able to solve problems in quite specific areas, but if one changes to another material or to another situation, even with a problem which seems to be closely related, lags of several months are noted, and in some cases even of one or two years.

Another problem is that although Piaget argues that each stage is necessary for the following one, he also proposed that some of the concepts contained within the stages of projective and Euclidean space develop in parallel and are mutually interdependent (Gerber 1981a, Ottosson 1987). This suggests that because of time lags and the overlap of stages there is a need to consider cognitive map representations of more than one familiar area in order to identify the 'general mapping ability' of primary school children, because they think differently about different situations and different places. Clearly as many different drawn cognitive map representations as possible would be best, but for practical reasons this research was concerned with two different areas.

In spite of the ambiguities, Piaget's theory of stages relating to Euclidean space influenced many researchers. Piaget's investigations of children's knowledge of space provided a model for the investigation of children's knowledge of geographic space. For example, based on Piaget's findings, Hart and Moore (1973) hypothesised that the development of the organisation of knowledge of the large-scale environment might also pass through three stages and referred to them as starting from:

Stage 1 relating to an egocentric system i.e. organised around the child's own position and actions in space

Stage 2 relating to several different possibilities of fixed reference systems – organised around various fixed, concrete elements or places in the environment

Stage 3 relating to an abstract or co-ordinated reference system, organised in terms of some abstract geometric pattern, including cardinal directions.

Hart (1979) used these stages in one of his tests concerned with children's model maps on paper (traced over by Hart) using sixty three children between the ages of four and nine years. The children's maps were sorted into three age groups before being placed into Moore's stages of organisation. Hart's results suggested that as the children grew older their cognitive map representations improved and showed more information. Relating the results to gender there were twice as many girls as boys placed at stage 1, slightly more boys than girls at stage 2, but at stage 3 there were twice as many boys as girls. Hart suggested that in 1979 boys were superior to girls in this particular test.

Matthews (1985a) used Moore's classification for placing children's drawn cognitive map representations into development stages. His results, broken down by gender, (relating to the children's home area maps) were:

	Stage 1 %	**Stage 2** %	**Stage 3** %
Girls	33.90	11.86	0.00
Boys	22.03	25.42	6.78

These results showed that there were more girls than boys at stages 1 and 2. None of the girls but 6.78% of the boys were placed at stage 3. Matthews suggested that the home area maps show that some six-year-old boys had achieved stage 3 and by nine years of age none drew stage 1. From the age of seven the majority of boys were drawing stage 2 maps and all had abandoned stage 1 by the age of eight. On the other hand, the results relating to the girls showed that stage 1 was the dominant mapping mode until the age of nine years and even some eleven year old girls were placed at this stage. In 1985 this type of research showed that boys were superior to girls. However, irrespective of gender, children's drawn cognitive map representations improved and showed more information, as the children grew older.

Piaget's theory of stages relating to Euclidean space also influenced Appleyard's (1970) research. Although it was mainly concerned with adults, he acknowledged that his methods used Piaget's findings on the child's conception of space as a basis with his topological, projective and Euclidean stages. In Appleyard's research, the adults were asked to draw two maps, one of a city, and one of their local area.

> The maps predominantly used sequential elements (roads) or spatial elements (buildings, landmarks or districts). The most accomplished maps employed combination of both elements.
>
> (Appleyard, 1970, pp.100-117).

Ladd's (1970) research was concerned with adolescent boys (12-17 year olds), who were asked to draw a map of their neighbourhood. She used a technique for organising the data which involved the development of descriptive categories which would take into account form and content elements as criteria in the drawings and four stages were devised as follows: -

Stage 1. Drawing is pictorial. The subject represents houses, other buildings, and elements that might be part of a street scene

Stage 2. Drawing is schematic. It contains lines or areas, which are not clearly connected to each other. It is poorly organised.

Stage 3. Drawing resembles a map. It is well organised, that is, the connections between the areas are clear. It could be used for orientation to the area.

Stage 4. Drawing resembles a map with other identifiable landmarks that would make the area recognisable. Connections between areas are clear. Could be used for orientation to the area

Each of the above researchers acknowledged Piaget's stages of development and have addressed Piaget's stages in order to construct their own techniques for placing drawn cognitive map representations into developmental stages. But the problem of trying to place children's drawn cognitive map representations into stages of development is that the majority of primary school children are placed within the projective stage. Catling (1978) addressed this problem by dividing Piaget's projective stage into two stages of cognitive map representations, namely, a projective one stage and a projective two stage. He produced an illustrated table (Figure 1.3) relating it to Piaget's Euclidean theory, showing the developing stages of cognitive map representation. He stressed that: -

> this is a composite overview of the developmental sequence of cognitive map representation, since no detailed research has yet proposed a definite qualitative structure.
>
> (Catling, 1978, p.120)

Catling acknowledged the findings of Moore's (1974 /1976), Appleyard's (1970&1973) and Ladd's (1970) methods when constructing his composite overview. Catling's four stages are as follows: -

Topological Stage Catling describes this as an egocentric stage, and gives the name of 'link-picture map' to these representations. The content is highly egocentric and only known places are shown, and these are connected to the children's homes. The representations are purely iconic and cartographic concepts and skills, such as direction, orientation, distance and scale are non-existent. It is an uncoordinated map.

Projective One stage is a quasi- egocentric stage in which children are able to represent their localities as quasi-maps, possessing more detail and better co-ordination. The continuity of routes, direction, distance and scale are all improved within their mapping, but still inaccurate. Roads are in plan form, but the buildings are still iconic. As children's understanding develops the map becomes more sophisticated, but a picture map still tends to dominate. Personally significant features tend to be exaggerated in size, but the drawing is beginning to take on the form of a map, although routes tend to dominate its structure. Scale and distance are inaccurate and there is little development of perspective.

Projective Two stage is a quasi-abstract stage and develops at the point when children's cognitive mapping ability evolves into the stage of abstract spatial reasoning when they realise that the map concept involves the display of pattern and control over the area from the vertical viewpoint. The quasi map now resembles a conventional map. Concepts such as direction, orientation, distance, scale perspective and a continuity of routes have improved. At the same time while some of the buildings are in plan form others are still in an iconic form.

Euclidean Stage. This stage is abstract and Catling identified this map as a true map. He suggested that at this stage it is accurate and detailed. Direction, orientation, distance, shape, size, and scale are all roughly accurate, and because the map is in plan form a key is required.

Table 1.3 is a table of comparison showing the differences between chronological ages and stages of development relating to Piaget and Catling.

Catling's illustrated table (Figure 1.3) has been generally accepted by theorists and used for assessing and placing children's drawn cognitive map representations into developmental stages, by providing a more explicit method than trying to use Piaget's explanations of the various stages of development. However, Wickstead (1991) found there was still a need to reduce the subjective element of the interpretation of the children's drawn cognitive map representations. A possible solution would be to use Catling's illustrated table as a starting point and make his comments more explicit by constructing an objective checklist.

Table 1.3. Differences between chronological ages and stages of development

	Birth to approx. 5 years	**approx. 5 to 7 years of age**	**approx. 7 to 11 years of age**	**Approx. 11 years of age**
Piaget's theory of intellectual development	Sensori – motor	pre-operational thought	concrete operational thought	Formal operational thought
Piaget's theory of Euclidean spatial development		Topological stage	Projective stage	Euclidean stage
Catling's developing stages of cognitive map representation		Topological stage	Projective One and Two Stages	Euclidean stage

Another problem highlighted in Wickstead's (1991) research was that a number of children's drawn cognitive map representations could not be placed into a stage of development and were therefore recorded as "non-scoring". (Table 1. 4)

Table 1.4 Catling's stages of development (1978) used by Wickstead (1991)

Stages of Development	**percentage of children placed within each developmental stage.**
Non-scoring	15%
Topological	19%
Projective One	29%
Projective Two	35%
Euclidean	2%

Although 15% of the children's drawn cognitive map representations could not be placed into a stage of development, a large percentage of the children who constructed these drawn cognitive map representations did score in other variables relating to general mapping ability, that were not dependent solely upon the ability to draw, such as giving verbal directions. Piaget and Inhelder (1956 pp 4-6) suggested that, " by noting the spontaneous remarks of children aged between eighteen months and four years their earliest spatial reactions may be observed - Their sense of direction is quite good - if we walk home with them - they manage to show the way quite well". Although Blaut (1991 p62) was concerned with children under the age of three years, he addressed this problem by referring to it as 'Natural Mapping'. He stated that:

> I must emphasise again that we know very little about the behavioural manifestation of these skills for children younger than 3.0, so the problem lies in the realm of theoretical model building. The model, which seems most plausible, is a conception of a mapping ability, which emerges naturally, that is, without teaching, in infants.
>
> (Blaut, 1991, p.62)

Both Piaget and Blaut imply that although very young children are unable to record their cartographical concepts and skills through the drawing of maps, they do have the ability to verbally identify cartographic directions, and that mapping ability emerges naturally. This leads to the question, "should an emergent or pre-stage in the developing stages of the drawn cognitive map representation be acknowledged, because children who cannot be placed into any of the present stages of development, do possess general mapping ability?". If one takes the view, that in the teaching of reading, writing and drawing there exists an emergent stage, which is a valuable part of progression within the teaching process, and not identified as "just pretend" or "cannot read, write or draw" - then perhaps there should be a pre- or an emergent mapping stage included within these stages of development.

Attempts to construct Piagetian scales in other domains of concept development have been made. Problems have been met and addressed similar to Catling's (1978) method of dividing Piaget's projective stages of development into two stages of development. Research by Shayer & Adey (1981) and Adey (1988) was concerned with developing a teaching pack within the domain of science education for secondary school children. They argued that the attraction of using the Piagetian model was that it should be possible to develop from it two sorts of measuring instruments, one for measuring the level of development and two, for determining the level of complexity of curriculum material. Their research involved some 12,000 pupils from middle, comprehensive and selective schools in which two major types of thinking can be identified. Younger and less able pupils would be limited to the use of concrete operational thinking, while older and more able pupils will be able to handle abstractions and many-variable problems, which is a characteristic of formal operations. (Table 1.3) Shayer and Adey suggested that each of the stages be divided into early and late phases. For example:

1. pre-operational
2a early concrete operational
2b. late concrete operational
2a/3a. transitional
3a. early formal operational
3b. late formal operational

The results showed that by 9 years of age, only about 30 per cent of pupils are using concrete operations fully, and one must go to 14 years before this rises above 75 per cent. At 14 years only 20 per cent are using 'early formal operations'. Shayer and Adey claim that although the developmental sequence Piaget described is confirmed, the ages of attainment of each stage are significantly higher than those suggested by Piaget. They suggest that Piaget's picture of human development must be modified very considerably.

Matthews (1992) also suggests there is a growing body of opinion, which is critical of Piagetian interpretation. Critics of Piaget suggest that we should be cautious in recognising both stages and ages of development. One of the reasons for young children's under-performance of tasks of spatial comprehension is the way in which test material is presented. Matthews argues that children do not necessarily view the world as egocentrically as Piaget suggest. In Piaget's 'model of a mountain task', children between the age of four and seven years attributed their own perspective to that of the doll. Children between the age of seven and eight years appeared aware of other perspectives other than that of their own, but operated imperfectly on these. Children between the age of nine and ten years generally gave correct answers. From these observations Piaget concluded that very young children, especially those under seven years of age would have difficulty with maps, since the maps not only provide a non-egocentric view of large-scale space, but also their aerial dimension was beyond the experience of most children. Blaut (1997) also argues against Piagetian interpretation because the results of his research indicated that very young children could readily learn map skills and macro-spatial concepts. Studies by Blaut et al (1970), and Stea and Blaut (1971) and Blaut and Stea (1973) tested with young children between the age of three and eleven years, using vertical aerial photographs as surrogate maps. Their findings indicated that children of school-entering age could interpret vertical aerial photographs without formal training. In a more recent study, Blades et al (1998) indicated that in addition to four-year-old children having the ability to interpret a vertical aerial photograph, they could also perform a simulated navigation task on it.

Researchers have also noted the tendency of Piagetians to underestimate cognitive abilities in young children by mistaking linguistic limitations for cognitive incompetence (Blaut 1997). For example, Donaldson's (1978) criticism of Piagetian interpretation suggested that children may reach different answers in tasks, not because of their spatial ability, but because their ability to use language is in advance of their ability to understand language. She argues that the understanding of the question put to children is one of the factors determining the way they behave in tests and at least two questions have to be distinguished if confusion is to be avoided. They are," Does the child understand the words he hears in the sense that they are in his vocabulary?" and "Does the child understand the words in the ways in which the speaker means the child to?" For example, Donaldson quotes a story told to three to five year old children about a 'hare' in a field, a walk along a 'quay' and a 'wing' in a castle. When questioned about the meaning of a 'hare', they touched their hair, indicated that a 'quay' was used for opening doors and a 'wing' was part of a bird. In addressing Hughes' (1975) 'policeman tasks' research, Donaldson (1978) suggested that Hughes was careful about introducing the tasks in ways that would help children to understand the nature of the problem. The research involved thirty children (between 3.5 and 5 years of age) and a tabletop model of two 'walls' intersecting to form a cross, producing four separate areas. This task was similar to Piaget's 'mountains' task, but instead of using the children's point of view, the instructions to the children were altered. The children were shown two dolls (one representing a child and the other a policeman). They were asked to "hide the child so that the policemen cannot see it". The policeman was placed in two of the four areas, while the other two areas were hidden from the policeman by the wall. The results indicated that 90% of the children's responses were correct, indicating that they could project themselves into another point of view. These results were inconsistent with Piaget's results, indicating that children of this age were still at the egocentric (topological) stage of development, because they could not project themselves into another point of view. Donaldson suggested that Hughes 'policeman' tasks gained more success than Piaget's 'mountains' tasks, because the task and instructions made more sense to the children,

Johnston's (1988) research, involving young children (between 2 and 4.8 years of age) is another example of opinion, which is critical of Piagetian interpretation and is concerned with language and development. She suggested that children learn new words and new usages as their repertoire of spatial concepts expands and these are the starting point of a developmental model. The results showed that the terms 'in', 'on', 'under' and 'next to' consistently preceded the directional terms of 'between' and 'in back of/ in front of'. The 'next to' judgements requires single decisions about the proximity of points, whereas 'in back of' judgements require the co-ordination of the observer and two points. From the results of her research, she concluded that some aspects of later projective and Euclidean systems are constructed early in childhood.

The above discussion has been concerned with criticism against Piagetian interpretation, but some researchers such as Downs and Liben are in agreement with Piagetian interpretation. Liben and Downs tested children (between the ages of five and seven years) in both a series of map tasks and a series of Piagetian tasks. The children's performance on groups of map tasks was compared to their ability to perform projective and Euclidean tasks (Liben 1981; Liben 1988). Blades (1989) reviewed a major study by Liben and Downs (1986) concerned with tasks such as: (1) the children describing what they understood by the concept of a 'map' by classifying maps, photographs, pictures, etc., as maps or non-maps; (2) drawing sketch maps and using symbols; (3) transferring information from one map or representation to another representation and working at different scales; (4) identifying locations (e.g., the position of objects on a classroom map); (5) working out directions on a map (e.g., which way the child or another person was facing or using compass directions); and (6) indicting routes (e.g., drawing a path on a map to show the route walked by a person). The same children were also given a series of Piagetian tasks which included adaptations of tasks which involved placing figures on a model landscape; perspective-taking tasks; and judging the accuracy of waterlines and plumblines on drawings (Piaget and Inhelder, 1956; Piaget et al., 1960). These tasks were used to assess Piaget's notion of the children's projective and Euclidean spatial abilities. The children's performance on groups of map tasks was compared to their ability to perform projective and Euclidean tasks, and there was a correlation between the children's ability to perform certain map tasks and their achievement on the Piagetian tasks. For example, there was a significant correlation between the children's ability to carry out tasks with unaligned maps and their success on the projective Piagetian tasks. Liben and Downs suggest that the ability to use an unaligned map depends on being able to adopt a particular point of view and that this is only achieved when children reach the projective stage of spatial development as indicated by the Piagetian tasks. Blades (1989) continues his review by suggesting that the general conclusions based on correlations between aggregate scores on a group of map tasks and a group of Piagetian tasks fail to explain the detailed development of children's map using abilities and strategies. Nonetheless, the study by Liben and Downs is important because many of their results indicate the competence of young children on many map exercises.

However, Blades (1989) concludes that although Piagetian theory may provide a framework for understanding children's spatial development, its description of spatial development in terms of a small number of general stages cannot explain the detailed progression of children's ability in different map tasks. On the other hand Weigand (1993) argued, although a sequence of development has been established, there is no agreement that children do pass through such stages.

The literature relating to a qualitative approach addressed the interpretation of children's drawn cognitive map representations relating to stages of development. The following section to this chapter addresses the literature relating to a quantitative approach.

THE LITERATURE REVIEW

General mapping ability

Measured through a quantitative approach

Catling's (1978) qualitative method (figure 1.3) can also be used in a quantitative way, because it identified individual cartographic concepts that are contained within each stage of development. For example, some concepts such as direction, roads and routes are contained within Catling's projective one stage. Plan form, distance and scale are contained within his projective two stage and size, shape and a key are contained within his Euclidean stage. As mentioned earlier, the term 'general mapping ability' embraces the following variables contained within the umbrella term of:

drawn cognitive map representations relating to
developmental stages
cartographic concepts
cartographic features

verbal cognitive map representations relating to:
verbal directional responses
verbal environmental perception responses
large scale Ordnance Survey maps
vertical aerial photographs

Cartographic concepts

As mentioned above, Catling's method for interpreting children's drawn cognitive map representations and placing them into developmental stages can also be used in a quantitative way, because it identifies individual cartographic concepts. Harwood and Usher's (1999) research was concerned with assessing progression in children's map drawing skills. The first phase of their research involved thirty-nine eight and nine year old children divided between a control and research group. Both groups were asked to draw a map of the route from their school to the church. The research group was taught separate map drawing skills and produced four maps each over a period of four months. In addition to Harwood and Usher used Catling's method for placing children's drawn cognitive map representations into developmental stages, they also designed a system for assessing children's map drawing abilities based on spatial arrangement, scale and proportion, perspective, abstraction/symbolisation, content (line maps) and content (area maps). The results indicated that overall there were positive gains from the teaching programme, the cumulative average performance per child showed an improvement with each map. However, the girls started at a higher average level than the boys and showed more progress on their second maps. But the girls made no further progress whereas as boys continued to improve on their third and fourth maps. By the end of the first phase the boys had improved their cumulative average score by +2.8 compared with +1.3 for the girls.

Taylor's (1998) research involved 263 children aged between four and eleven years (122 boys and 141 girls). In order to assess their mapping ability they were given the following instructions:

> You are going to organise a party and people are coming to your house from all over town. To make sure everyone gets to your house, on time, you decide to draw a map to send out with the invitations. Try to cover as wide an area as possible, and do not forget to include any features, which may help your guests to find the way.
>
> (Taylor, 1998, p.14)

The children in Taylor's research were given a sheet of A4 paper and fifteen minutes to complete their maps. The cartographic concepts being assessed were area, features, accuracy, scale organisation, plan view, labels, key, grids and symbols and each map were numerically graded from 1 to 5. To give a rating for overall mapping ability the scores for each of the cartographic concepts were aggregated. The results indicated that boys tended to cover a greater area and were more likely to use plan view than girls. They also produced a wider range of maps than did girls. But the girls drew more details and were more accurate than the boys beyond the age of eight years.

O'Laughlin and Brubaker's (1998) research was concerned with gender differences in the self report of spatial abilities, a mental rotation test and the production of a drawn cognitive map representation. The testing involved 78 male and 82 female college students who viewed a videotape of the interior of a three bedroomed house and asked to draw a sketch map of the floor plan. Half of the students viewed a three-minute video tour of a furnished house, while the other half viewed a video tour of the same house unfurnished. Their results indicated that men performed significantly better than women on the mental rotation test. Although no gender differences in mapping accuracy were found, both men and women drew more accurate maps when provided with landmarks (furnished house) as compared with the unfurnished house condition. Although women performed as well as men in the cognitive mapping task they reported a lower level of confidence in the accuracy of their sketch maps as compared with men. According to O'Laughlin and Brubaker these results indicated that:

> while men and women may process their environment in a different manner such that women display a strength in utilizing landmarks while men exhibit strengths in Euclidean type spatial abilities, both reach the same end point with no apparent gender differences in the final performance on selected navigational type tasks.
>
> (O'Laughlin and Brubaker, 1998, p.600)

Liben and Down's research (Liben 1997) involved several studies involving tasks concerned with cartographic concepts. For example, children (5-11 years) were asked to draw maps of their classroom and of their school. The results indicated that with age, there was an increasing use of an overhead (plan) viewing angle and symbols. In another study (Liben and Downs 1986) found that some kindergarten children were able to draw a route on a map of their classroom to represent a path, which they had seen a person walk through the actual classroom. They also found that 84% and 95% of kindergarten and first grade children respectively could indicate their own position on an aligned map of their classroom.

Cartographic features

Matthews (1992 p100) suggested that the simplest way of measuring information on place was to count the amount of data correctly recorded on a child's sketch map. He terms this method as "mean information on place" (1984c), and used it in 1984 in three Coventry primary schools by testing one of the following variables in each school: -

i the drawn cognitive map representation ii the vertical aerial photograph

iii the large scale Ordnance Survey map

Two different environments were tested (the journey to school and the home area), because they were likely to be different in terms of their spatial form and in the way in which children interact with them. All children were given the same instructions, but the children's responses were measured in different ways. For example, in one school the children constructed drawn cognitive map representations on A4 sized paper. The children from the other two schools were given A4 sized sheets of tracing paper placed over, either a vertical aerial photograph or a large scale Ordnance Survey map and asked to trace their cognitive map representation.

Although Matthews devised his own method for measuring the content of children's drawn cognitive map representations for the above mentioned research, he carried out similar research in another Coventry school, using children between the ages of 6 and 11 years, but only addressing the features on drawn cognitive map representations. His testing followed identical procedure to his other research asking the children to construct two drawn cognitive map representations. He used Lynch's (1960) major organisational elements of paths, nodes, landmarks, area, district and edges (see previous chapter) as a means for recording different types of information from children's cognitive map representations. However, Matthews (1992) pointed out that: -

> Lynch's schemata are not without problems. Often there is considerable ambiguity over some of the elements. For example, in my survey many children drew attention to a prominent local church. It was decided to classify this feature as a landmark rather than a node, mainly on the use to which it was put.
>
> (Matthews, 1992, p.101)

Matthews' (1984c) research was to establish if gender had any influence on the types of features depicted on children's drawn cognitive map representations. He asked 172 children aged between six and eleven years to draw maps of two different familiar areas. Matthews then used Lynch's (1960) organisational elements to record the results. The results of his research, irrespective of gender, showed that the older the children the greater the number of correct features depicted on their maps. He also stated that before eight years of age there were only slight differences in gender, but from the age of eight gender differences were more evident. Boys' maps were consistently better than girls' maps showing more detail because, as according to Matthews, boys enjoy more freedom of movement and this leads to a fuller appreciation of roads, paths and nodes. Girls on the other hand identified more landmark and area/district features, but their more restricted experience of place leads to a less sophisticated map (Matthews, 1984c p333).

Wickstead's (1991) research was another example of measuring cartographic features. This involved seventy-two primary school children who were asked to construct two different but familiar drawn cognitive map representations. One map involved the school and its perimeter and the other map involved a journey from the school to McDonald's situated on a retail park approximately three miles in distance away from the children's school. The number of cartographic features from both the initial and final drawn cognitive map representations was combined and the following observations were made: -

Relating to Gender

Girls identified more cartographic features than boys (for both school and other familiar test areas) on their drawn cognitive map representations.

Relating to Year Groups

The results showed that although there was a wide difference in the number of cartographic features shown on the children's drawn cognitive map representations between the Reception/Year 1 and Year 6 groups there was no developmental pattern between the six-year groups.

Relating to Gender and Year Groups

The Reception/Year group 1, Year group 3, and Year group 6 girls identified more cartographic features than boys. Year group 2 children showed no gender difference and Year group 4 and 5 boys identified more cartographic features than girls. It is not possible to state if these differences were significant, because testing for significance was not carried out at the time of the research and the data is no longer available. However, Matthews' and Wickstead's different results add to the general uncertainty of the gender issue.

Verbal directional responses

Wickstead's (1991) research was concerned with the interpretation and uses of drawn cognitive map representations, testing children between five and eleven years of age. The children were asked to draw maps of two familiar areas, in order to indicate a comprehensive picture of their mapping ability. After the children had constructed their drawn cognitive map representations, one-to-one discussions between the researcher and children took place, the aim being to elicit the children's verbal directional responses because as Boardman (1990 p59) suggested, "there is always the possibility that children may know far more about their spatial environment than they are able to draw on paper". The variable of verbal directional responses was one of several variables being tested and measured using a quantitative approach, but only in a simple manner. This was achieved by counting the number of different directional terms used and the data analysed into mean average and percentage scoring and not tested for statistical differences. More verbal directional responses were made by the sample as a whole relating to the McDonald's map area than for the school and its perimeter map area. A developmental pattern emerged between the year groups and the number of responses made apart from the Year group 3 children who made more responses than Year groups 4 and 5. Relating to gender differences, the girls as a whole, apart from Year group 5, made approximately 25% more verbal directional responses than the boys.

Blades and Medlicott's (1992) research involving four groups of children and one group of adults was concerned with assessing how route directions were given from a map. Their results showed that although the six and eight year old children were unable to give correct route directions, when describing routes they mainly focused on landmarks. Although cardinal direction was included in the testing it was rarely used by any age group. Overall there was a clear age related improvement but no gender differences.

Denis's (1997) research was concerned with the analysis of description of routes and suggested that there are two essential components of route descriptions. The first refers to landmarks, mainly 3d physical objects, such as a church, bus stop or a signpost. Two-dimensional features such as streets, squares or roads can also be used as landmarks. The second set of components is those, which prescribe actions such as "Go straight ahead" or "Turn right". The research involved 20 students (10 men and 10 women) aged between 19 and 26 years. Two familiar routes were used for the testing. For example, Route 1 was the route between the train station and the Students Residence.

> "Suppose that you are to be visited by a person who has never been to the Orsay campus before. This person comes from Paris by train and gets off at the Bures-sur-Yvette station. He/she has to meet in the entrance hall of Building B of the Students Residence. What description would you give this person to be sure that he/she finds his/her way?"
>
> (Denis, 1997, p.425)

The students' responses were recorded on audiotape and classified into five different classes. For example, Class 1 included prepositions describing an action without referring to any landmarks such as "Turn left" or "Walk straight ahead". Class 2 included both actions and landmarks. Class 3 introduced a new landmark into the route. Class 4 described a landmark and Class 5 was concerned with commentaries such as, "It will not take long". The results relating to gender differences indicated that females describing routes devote more attention to landmarks than males.

Environmental Perception

Hart (1979) interviewed 65 children on their likes and dislikes of familiar places. Although he used four major categories (land-use, commercial, social and aesthetic) for measuring in a quantitative method, he suggested that there was no satisfactory, straightforward method for sorting children's responses into categories. He extracted place categories, for example, "jumping places, climbing places, paths, graveyards etc." (pp 454-6) from the children's responses, using simple categories that could be compared with his "place-use" data. His data was analysed simply and expressed in % frequency tables. Although his results showed that overall the boys gave more responses (52% of the total responses) than the girls (48%), the gender difference was minimal. However, when the children's responses were divided into two age groups by gender, the first group (Kindergarten to Grade 3) showed that the boys gave more responses than the girls (60% of the total responses) and the other group (Grade 4 to Grade 7) showed that the girls gave more responses (56% of the total responses) than the boys.

Part of Joshi et al's (1999) research was concerned with children's perceptions of the environment. Ninety-three children aged between seven and eleven years of age were involved. They were invited to respond to four sets of drawings depicting hypothetical routes home and one set of photographs depicting possible play areas. The children were asked to imagine they were walking home from school on their own. For each of the four sets of drawings they were asked to specify their most and least preferred routes home and to give reasons for their decisions. Their results indicated that pollution such as (noise or smells) were negatively mentioned by 70% of the children and feelings of traffic danger by 68% of the children. The most disliked place was the towpath by an industrial canal (56% of the children).
The children were then shown photographs depicting possible play areas of an environment beyond the school journey. They were asked to choose the area in which they would most like to play and the area in which they would least like to play and to justify both choices. Among the photographs of potential play places the most favoured place was the path through the wood, chosen by 63% of the children.

Large Scale Ordnance Survey maps

Matthews' (1987) research investigated the influence of gender related differences and involved 166 children aged between six and eleven years. The interpretation of large scale Ordnance Survey maps was one of the techniques used with one-third of the children taking part in the research. Only the number of features correctly identified on large scale Ordnance Survey map was recorded. The results showed that both boys and girls identified more features on their home area maps than on their journey to school maps. The six-year-old girls (Year 1) identified more features than the boys for both test areas relating to the journey to school the seven, eight and ten year old boys (year groups 2, 3 and 5) identified more features than the girls.

There was no gender difference for the nine and eleven year old children (year groups 4 and 6). Relating to the home area test, apart from the six and eight year old girls (year groups 1 and 3), the boys in the other five-year groups identified more than the girls. Table 1.5 shows an extract from Matthews (1987, p47) relating to map interpretation and outlining his results for both test areas, showing the ratio between genders.

Table 1.5 Matthews (1987) showing mean number of elements per map

AGE	6yrs	7yrs	8yrs	9yrs	10yrs	11yrs
Mean No. elements per map						
Journey to school map						
Boys	1.6	2.5	2.8	3	4.8	4.3
Girls	2.3	2	2.3	3	4.7	4.3
Ratio	0.7	1.3	1.2	1	1	1
Home area map						
Boys	1.6	3.1	4.3	7.1	8.7	8
Girls	1.8	3	4.5	4.8	5	5.7
Ratio	0.9	1	0.9	1.5	1.7	1.4

From these results Matthews indicated that boys were superior to girls in this particular general mapping variable.

Vertical Aerial Photographs

In the late 1960's and early 1970's, Blaut and Stea carried out several studies involving over 500 children (3-11 years of age) in Massachusetts, Puerto Rico and St.Vincent using vertical aerial photographs as surrogate maps (Blaut et al 1970; Blaut and Stea 1973; Stea and Blaut 1971). One group of studies with five and six year olds from each of the three areas showed that almost all children of this age could identify some of the features depicted on vertical aerial photographs. These children had no prior exposure to aerial photographs, no training, and, in the case of St. Vincent, no prior exposure to television. The procedure for testing has been described earlier in this chapter. The results indicated that children of school-entering age could interpret vertical aerial photographs without formal training.

In 1968, they tested 35 kindergarten children from four Puerto Rican communities in aerial photo interpretation. centering on the school attended by the children. The communities were representative of urban middle class, urban lower class, coastal plantation, and mountain peasant areas. The results indicated that all except the urban lower-class children produced about the same number of total responses; the latter produced fewer. However, the urban middle-class group produced substantially more correct responses than the others, who were about equal in this respect. Features such as houses were most frequently pointed out, followed closely by motor vehicles, roads and streets, and, with some-what less frequency, trees. The ordering, however, was different for each group. Roads were most significant in the urban-middle and plantation communities, vehicles in the two urban groups. Urban middle-class children most frequently recognized both houses and trees.

In 1969 they carried out further a further study in Puerto Rico involving children from the second, fourth, and sixth grades of the same schools involved in the previous study. A total of seventy-six students from the mountain peasant community and ninety students from the urban middle-class community were tested. The results were combined, in part, with those from the kindergarten children and the results indicated that some children can read aerial photographs at the age of five, can trace "maps" from these photos at a slightly later age and use these maps to draw trip routes. The results also showed a developmental pattern from the age of five through to nine years, but after the age of nine there was a leveling off, indicating that the ability to interpret vertical aerial photographs is fully formed by the age of nine. Hence, with cross-cultural data from nearly 500 children, they state that children are able to read and use aerial photographs as maps. The findings also show that children who have never seen the earth from a vertical perspective can nevertheless recognize a landscape image in this perspective. Their results indicated that the basic components of mapping behaviour are displayed by young children is learned before they enter schooling, and a 'natural' form of map learning occurs as a normal developmental process in young children. They can explain these abilities only if we assume that a very highly evolved cognitive map has already been formed in many children by the age of five. The consistencies in their findings across cultural, geographic and social class backgrounds, lead them to suggest a 'cross cultural' ability to read maps and more importantly – an ability to understand the language of maps that precedes literacy.

However, Matthews' results were not consistent with the above research. The interpretation of vertical aerial photographs was another technique used by Matthews (1987). Again, only the number of features correctly identified was recorded. This research was carried out in the mid 1980's and one of the results was different to Blaut and Stea. Matthews' results showed that development in this particular variable did not taper off at nine years of age, but the development showed a continuous pattern for both boys and girls in both test areas, from the age of six through to eleven years. His results also showed a wide gender difference within each of the year groups. The boys identified more features on the vertical aerial photographs than the girls in each of the year groups and in both test areas. In addition to the above results suggesting that boys were superior to girls in this particular general mapping variable, both boys and girls identified more features on their home area maps, following the same pattern shown in the results relating to the large scale Ordnance Survey map variable.

Spencer's (1998) research involved 80 nursery school children and the results of the testing showed that oblique aerial photographs were easier for nursery school children to interpret than vertical aerial photographs. It was found that while children could identify some features such as houses and cars on both types of photographs, they had difficulty with other features e.g. none could identify a fence Only 14% of the children were able to identify the fence when it was pointed out on a vertical aerial photograph, but 63% of the children were able to identify it on the oblique aerial photograph.

A more recent study by Blades et al (1998) indicated that four-year-old children could read a vertical aerial photograph and perform a simulated navigation task on it. The procedures for the testing has already been outlined earlier in this chapter and the results of the testing are shown in Table 1.6

Table 1.6 The children and their performance (Source: Blades et al 1998 p274)

Study site	Number of children	Identifications (mean number correct)	Navigation (%correct)
York	20	5.2	70
Durban	20	6.6	60
Tehran	60	2.1	58
Mexico City	20	3.0	80
Evanston	24	4.1	88
Overall	144	4.2	71

Blades et al (1998, p.275) indicated that from these results, nearly all children in all sites identified at least one landscape feature on the aerial photographs; the means for correct identification at the different sites ranged from 2.3 to 6.6, the mean of the site means was 4.2. Relating to the navigational problem, the means of the different sites ranged from 58 per cent to 88 per cent and 71 per cent of the children overall solved the problem. The results showed that mapping abilities are well developed by the age of four years and provide some evidence that mapping abilities emerge without training in very young children of all cultures. These results bring into question of whether the development of spatial cognition proceeds more rapidly than is claimed in Piagetian theory in that children younger than about seven are 'pre-operational', hence cannot perform the cognitive 'operations' involved in map-reading.

> The findings suggest that mapping abilities, and macro-spatial learning as a whole, develop much more rapidly than is predicted in classical Piagetian theory, and that if, indeed, there is a discrete developmental stage in which Piaget's concrete spatial operations emerge, they must emerge in children at or before the age of four.
>
> (Blades et al, 1998, p.275)

CONCLUSION

The literature review indicated that the following variables have been identified and methods developed for their assessment relating to the ability and development of children taking into consideration both age and gender:

i drawn cognitive map representations (Catling 1978),

ii cartographic concepts (Taylor 1998)

iii cartographic features (Matthews 1984c)

iv verbal directional responses (Blades and Medlicott 1992)

v Ordnance Survey map and aerial photograph interpretation (Matthews 1989c)

vi verbal environmental perception responses (Hart 1979)

However, to date there does not seem to have been an attempt to find a general measure of children's overall general mapping ability by amalgamating the results of the separate variables. It is clear that children respond differently when presented with problems framed in different ways (Piaget 1971). Consequently it cannot be assumed that a measure on any one variable can be extrapolated to form a measure of overall general mapping ability. As Spencer et al. (1989) suggest, caution is needed when recording children's responses and: -

> Asking young children to draw maps or give verbal descriptions is a fairly ineffective way to assess their environmental knowledge.... there is no doubt that failure to utilise appropriate methods has often led to the under-estimation of children's ability ... Any task that confounds environmental performance with other skills (whether drawing, verbalizing, estimating distances or direction etc.) should be treated with caution.
>
> (Spencer et al, 1989, p.12)

The first question emerging from the search of the literature was "Can a method be developed to measure children's overall general mapping ability?" If so, can it be used across the primary age range with a wide variety of pupils at different stages of development? The second question is: "Are there gender differences in general mapping ability?" Research by Matthews (1984c) relating to cartographic features on children's drawn cognitive map representations produced results that suggested boys were superior to girls in their general mapping ability. This was different to

Wickstead's (1991) research suggesting that girls were superior to boys. Taylor's (1998) research showed that boys tended to produce a wider range of maps than girls did. On the other hand, girls drew more details and were more accurate than boys beyond the age of eight years. The different results add to the general uncertainty of the gender issue.

However, the above findings only relate to one, or more variables being used for their assessment and not an amalgamation of all variables contained within the umbrella term of 'overall general mapping ability'. It is obvious that a more accurate result could be obtained if the testing was judged on all of the variables being integrated together. This would produce a more realistic and fairer assessment of children's overall general mapping ability. As Waller (1986) suggests:

> If only one aspect of children's knowledge is examined at a time, then developmental changes of style may go unnoticed. A case is made for the use of combined measures when investigating the many skills involved in environmental cognition. The study looks at whether it is fair to describe children as having deficient spatial representation, when most studies only test one representation.
> (Waller, 1986, p.109)

CHAPTER 2

THE METHODOLOGY

The literature review has shown that most of the general mapping variables have been separately tested, measured and the ability and development of children relating to both gender and the different year groups have been identified (Piaget 1955, Catling 1978, Hart 1979, Matthews 1984c, Blades and Medlicott 1992 and Taylor 1998). However, to date there has not been an attempt to find a general measure of children's 'overall mapping ability', yet it is clear that children respond differently when presented with problems framed in different ways (Piaget 1971; Matthews 1984a). Consequently it cannot be assumed that a measure on any one variable can be extrapolated to form a measure of overall general mapping ability. Therefore, the research question emerging from the search of the literature is, "Can a method using children's cognitive map representations (both drawn and verbal) be developed to measure children's overall general mapping ability?" If so, can it be used across the primary age range with a wide variety of pupils at different stages of development? In order to produce reliable and generalisable judgements about primary school children's overall general mapping ability, a standardised test is required. It is the main purpose of the research to construct and use such a standardised test in order to interpret and score children's cognitive map representations (drawn and verbal) and attempt to identify the present state of children's overall general mapping ability.

It is the purpose of the research to find the best technique to achieve as wide as possible coverage of the following variables in order to construct such a standardised test.

Drawn cognitive map representations

Developmental stages

Cartographic concepts

Cartographic features

Verbal cognitive map representations

Directional responses

Environmental perception responses

Ordnance Survey map interpretation

Aerial photograph interpretation

The first element to be addressed in the development of the instrument to be used in the standardised test was the construction of checklists to record children's responses relating to each of the above variables. The contents of the checklists took into account the definitions of general mapping terms by (Catling, 1978 & 1981; Bale, 1987; Mills et al, 1988; Harrison and Harrison, 1989; Boardman, 1990; Weigand, 1993; Marsden and Hughes, 1994). The second element was the development of procedures to be followed in order to elicit children's responses. The final element to be addressed was the testing, interpreting and scoring of the instrument. In order to test both the validity and reliability of the instrument, fourteen children (one boy and one girl, from each of the seven primary year groups) from one of three schools taking part in the main research took part in a pilot study. The purpose of the pilot study was concerned with the formal evaluation of the research methodology by testing the instrument (Gay 1992).

Liben (1997) argues that the most important methodological lesson is that:

> decisions about how much and what kind of knowledge should be provided in the instructions differ depending upon the research question. One must identify the focus question, and ensure that the instructions do not themselves constrain the outcome. Or to make the same point in reverse, if certain kinds of instructions are necessary for the child to understand the task, one must be careful not then to impute to the child spontaneous understanding or skill that may have resulted from exposure to the instructions. Irrespective of what particular questions, instructions and research traditions may be, it is important to include careful reports of what introductionory instructions are used because they are every bit as much a part of the method as the procedure that follows...
>
> (Liben, 1997, p.73)

This is reiterated by Donaldson's (1978) research, who suggested that children may reach different answers in tasks, not because of their spatial ability, but because their ability to use language is in advance of their ability to understand language. She argues that the understanding of the question put to children is one of the factors determining the way they behave in tests and at least two questions have to be distinguished if confusion is to be avoided. They are," Does the child understand the words he/she hears in the sense that they are in his vocabulary?" and "Does the child understand the words in the ways in which the speaker means the child to?" As well as children understanding what was being asked of them, it was equally important for the researcher to understand the children's interpretation of their drawn cognitive map representation. Therefore, one of the criteria to be considered in the construction of the instrument was 'one to one discussions'. No matter how explicit a feature looked on the drawn cognitive map representations, the researcher touched each feature and the child was asked, "What is this?" The aim was to objectively identify all features depicted by the children (including spaces if these appear relevant) and to record this information. For administrative purposes it was convenient to number every feature and record the children's verbal responses on their drawn cognitive map representations.

The ability to draw and the ability to verbalise their cartographic responses are important criteria and the instrument should include sufficient and appropriate tasks to achieve the overall objective of attempting to find a general measure of primary school children's 'overall general mapping ability'? As Spencer et al. (1989) suggest, caution is needed when recording children's responses because: -

> Asking young children to draw maps or give verbal descriptions is a fairly ineffective way to assess their environmental knowledge.... there is no doubt that failure to utilise appropriate methods has often led to the under-estimation of children's ability ... Any task that confounds environmental performance with other skills (whether drawing, verbalizing, estimating distances or direction etc.) should be treated with caution.
>
> (Spencer et al, 1989, p.12)

The following criteria formed a checklist that were both implicitly and explicitly addressed in the construction of the instrument to be used, in order to identify the overall general mapping ability of primary school children:

Reliability is the degree to which a test consistently measures whatever it measures. For example, the more reliable a test is, the more confidence we have that the scores on a test are the same scores that would be obtained if the test was re-administered (Gay, 1992). However, as the purpose of the pilot study was mainly concerned with the construction of the checklists and the instructions to the children prior to the main research being implemented, this criterion is discussed later in more depth.

Validity is the most important characteristic of any test, and a test is valid for a particular purpose and a particular group. In this case, the main purpose of the test was to identify the overall general mapping ability of primary school children (aged 5 – 11 years). Sampling validity is discussed in the following chapter when describing the choice of the population and stratified sample.

Objectives.

Criteria relating to objectives were contained within the four following research questions:

"Can a method be developed to measure children's overall general mapping ability?"

"Can it be used across the primary age range with a wide variety of pupils at different stages of development?"

"Should an emergent stage be included to accommodate children who could not be placed into a stage of development?

"Are there gender differences in mapping ability?"

Content

As previously mentioned it is the purpose of the present research to find the best technique to achieve as wide a possible coverage of the separate mapping variables in order to construct a standardised test. The construction and contents of the checklists to record children's (drawn and verbal) responses relating to each of the variables took into account definitions of general mapping terms. For example, the checklist relating to the 'stages of development' variable was based Piaget's

Euclidean theory and Catling's (1978) illustrated table (Figure 1.3) was used as a starting point and guideline. Catling's comments were changed into questions producing 'Yes/No' answers in order to make the interpretations of the drawn cognitive map representations more objective. Liben (1997) questions whether the measure should be the number of correct interpretations or the number of errors. Because the main research question is concerned with attempting to identify the 'overall general mapping ability' of primary school children, the decision to use correct interpretations was taken.

An implicit criterion concerned with the use of language was included, as it was important to establish if the pilot study children understood the words in the ways the researcher meant them to be understood (Donaldson 1978). It was equally important for the researcher to understand what was being conveyed to them (either drawn or verbal) in the way that children meant them to be understood.

Valid learning experiences

Four forms of criterial action were used to elicit the pilot study children's drawn and verbal responses relating to their overall general mapping ability:

i draw maps of two familiar areas, a) their school perimeter (Map area A, and b) Another specified familiar area approximately two to three miles from their school. (Map area B)

ii draw a route on both maps and verbally describe the route (in directional terms) relating to Map areas A and B

iii draw ('happy/unhappy' faces) against some features on both maps and then verbally describe their likes and dislikes (and reasons) for the inclusion of these features

iv verbally identify features on Ordnance Survey maps (1:12500), and coloured vertical aerial photographs (1:1000). The maps and photographs being adjusted to ensure that they were approximately the same scale and identified the same geographical areas as the children's drawn cognitive map representations.

Evaluation

The results of the children's learning experiences were recorded on the appropriate checklists and transferred to individual coded profiles. The data were collected, encoded and stored using the SPSS 10.0.5 for Windows 95/98/NT computer package. The criterion at this stage was to ensure that the results relating to the four questions outlined in the objectives could be examined by means of appropriate testing for statistical significance.

THE INITIAL DEVELOPMENT OF CHECKLISTS

Because different variables are being tested, different checklists are required to meet the purpose of each test. For example, procedures used to construct the checklist relating to primary school children's stages of development will be different from the procedures used to construct the checklist used to identify how many features on vertical aerial photographs can be correctly identified.

Developmental stages of drawn cognitive map representations

One of the problems in the development of the instrument was that once children had produced the drawn cognitive map representations, how could the features depicted on their representations be objectively interpreted and placed into developmental stages. Catling's (1978) illustrated overview was used as a guideline for the interpretation of the children's drawn cognitive map representations (Figure 1.3), but with some reservations. It was considered important to make more explicit Catling's criteria relating to his Developing Stages of Cognitive Map Representation. This was achieved by constructing a checklist (Figure 2.1) for interpreting and scoring, taking into consideration a) the instructions given to the children prior to the construction of their drawn cognitive map representations, and b) changing Catling's comments on his illustrated table into questions producing a "Yes" or "No" answer.

Figure 2.1

CHECKLIST (AND INSTRUCTIONS) OUTLINING THE INTERPRETATION OF CHILDREN'S DRAWN COGNITIVE MAP REPRESENTATIONS AND PLACING THEM INTO DEVELOPMENTAL STAGES

PILOT STUDY

Child number ____ Sex ____ Year group ____ Area School

EMERGENT STAGE Start at the Topological Stage. Does the child fulfil the requirements of the Topological Stage? If the answer is NO, the child is at the Emergent Stage and this will be addressed later	YES/NO
TOPOLOGICAL STAGE Link Picture MAP Does the route (arrow/ line that can be broken) start near the school gate? If answer is NO, the child is at the Emergent stage. If answer is YES, continue to next stage	YES/NO
PROJECTIVE ONE STAGE Are any roads or paths or pavements shown, in addition to the route?	YES/NO
Sufficient detail. Have at least eight features been identified? (Do not include discrete features)	YES/NO
Direction. Does the route (arrow or line) start at the school gate and finish in the junior playground? (Breaks in continuity accepted)	YES/NO
Orientation. Does the route (arrow or line) start at the school gate and finish in the junior playground? (Breaks in continuity accepted)	YES/NO
Perspective. Look at the OS map showing the route. Are there any features on the child's drawn cognitive map representation that the child cannot visually see, if he she walked the route?	YES/NO
PROJECTIVE TWO STAGE Plan form. Are any of the buildings in plan form?	YES/NO
Sufficient detail. Have more than eight features been identified on the map? (Do not include discrete features)	YES/NO
Perspective. Look at the OS map showing the route. Are there any features on the map that the child cannot see, if he/ she walked the route? Features must be connected by road.	YES/NO
Continuity of routes. Does the route (arrow or line) start at the school gate, follow instructions and finish in the junior playground? (breaks in continuity NOT accepted)	YES/NO
Continuity of roads Does the road start at the gate and finish near the junior playground gate? (Breaks in continuity NOT accepted)	YES/NO
Improvement in direction. Does the route follow the road/path, start the school gate and finish in the junior playground? (Breaks in continuity NOT accepted)	YES/NO
Improvement in orientation. Does the route follow the road/path, start the school gate and finish in the junior playground? (Breaks in continuity NOT accepted)	YES/NO

Distance. Is the shape of the child's map similar to the route marked on the OS map of the same area?	YES/NO
Scale. Is the shape of the child's map similar to the route marked on the OS map of the same area and are similar features the same size and shape?	YES/NO
EUCLIDEAN STAGE A true map. Is the map in plan form and can it be read and understood completely?	YES/NO
Accurate and detailed. Does the map accurately show more details, than those asked for in the instruction? (At least thirteen features should have been identified. Do not include discrete features)	YES/NO
Does it reasonably resemble the Ordnance Survey map of the area and the researcher's instructions? Are the following concepts roughly accurate and similar to the O. S. map of the area?	
Direction	YES/NO
Orientation	YES/NO
Distance	YES/NO
Scale	YES/NO
Shape	YES/NO
Size	YES/NO
Key. Does the map contain either a key, or are all features labeled	YES/NO
PLACING THE CHILD INTO STAGES OF EUCLIDEAN DEVELOPMENT. (Underline the appropriate stage) The "Yes/No" answers on the checklist will explicitly show the relevant stage. EMERGENT STAGE TOPOLOGICAL STAGE PROJECTIVE ONE STAGE PROJECTIVE TWO STAGE EUCLIDEAN STAGE	
CHILDREN'S UNDERSTANDING OF CARTOGRAPHIC CONCEPTS The "Yes/No" answers on the checklist will explicitly show the child's understanding of the cartographic concepts listed below. These concepts can be recorded on the drawn cognitive map representation. If no concepts have been understood, record on drawn cognitive map representation as "Emergent stage." Route shown — Roads/paths shown Direction — Orientation Perspective — Continuity of routes Buildings in plan form — Continuity of roads Improvement in direction — Improvement in orientation Distance — Scale Shape — Size Key or complete labeling	

The instructions to the children were in the form of a 'story' that contained all the information they required to draw their maps, but they were given only minimum cartographic instructions. Directional terms were kept to the minimum, as the verbal identification of these terms was an explicit part of the tests. The children were also told that only one piece of paper could be used for one map. This was to enable the researcher to identify the children's understanding of the cartographic concepts of scale, distance, size and shape. A more detailed description of the instructions given to the children is addressed later in this chapter.

As mentioned above, Catling's comments on his illustrated table were changed into questions producing a "Yes" or "No" answer (Figure 2.1). For example, one of Catling's comments at his projective one stage was "direction more accurate". This comment was changed to "Does the route (either an arrow or line, breaks in continuity allowed) start at the school gate and finish in the junior playground?" Catling's comment regarding direction was slightly ambiguous, because at his topological stage, direction is mentioned as non-existent. To acknowledge some progression, from "non-existent" to "more accurate", the question for the topological stage is "Does the route (either an arrow or line, that can be discontinuous) start at the school gate?" At Catling's projective two stages, direction was "improved". This comment was changed to "Does the route follow the road or path (either an arrow or line, no breaks in continuity allowed), start at the school gate and finish in the junior playground?" Finally, at the Euclidean stage, Catling's comment was that direction should be roughly accurate. This comment has been changed to the question, "Have the researcher's instructions relating to direction been followed, and is the direction of the route shown on the children's drawn cognitive map representation roughly accurate and similar to the Ordnance Survey map of the area being tested?"

The term "more detailed" in Catling's comments relating to the projective two stage was changed to "sufficient detail" and for the purpose of this research this term needs to be defined. At least twelve cartographic features were identified on a section of a large scale Ordnance Survey map (Figure 1.2) relating to the perimeter of the school taking part in the pilot study and the route described in the instructions, by the researcher. These features could have been drawn by the children relating to the route mentioned in the instructions, namely: -

the main school building
temporary classrooms
pavement
two roads
infant playground
junior playground
playing field
nature trail
houses
garages
gardens

Taking into consideration the different ages and developmental stages of children taking part, the number of features within each stage were required to contain an element of progression. At least four features (out of a possible twelve) were required to be identified on the children's drawn cognitive map representation at the topological stage. The justification for using this quantity was because in the instructions prior to constructing their drawn cognitive map representations, using a basic map technique (Kitchen & Blades 2001), the children were told that their maps must include the school, school gate, pavement, and railings and junior playground. Between five to eight features were required as sufficient detail at the projective one stage, and more than eight features at the projective two stage. It was assumed that, because of the element of progression, more than twelve features were required to be shown on the children's drawn cognitive map representations in order to justify 'sufficient' detail at the Euclidean stage of development.

An emergent stage was included on the checklist (Figure 2.1) to take account of Wickstead's (1991) research, when a number of children's drawn cognitive map representations were recorded as "non-scoring". Although no cartographic concepts were identified on the drawn cognitive map representations, most of these children were given a quantitative score when presented with other general mapping variables that required verbal responses. For example, the children were able to express both cartographic directional vocabulary in terms of the route outlined in the instructions and environmental perception responses relating to the their likes and dislikes. The emergent stage of development is addressed later in this chapter. Figure 2.1 is an example of the checklist constructed as part of the instrument to be used to interpret children's drawn cognitive map representations relating to the developmental stages variable.

Cartographic concepts

The development of the previous checklist (Figure 2.1) relating to the drawn cognitive map representation developmental stages served two purposes. In addition to placing children's drawn cognitive map representations into developmental stages, it also identified the cartographic concepts understood by the children that produced a quantitative score These cartographic concepts, already identified on Figure 2.1 were explicit and easily transferred to a checklist producing a quantitative score (Figure 2.2).

Most of the concepts have been shown more than once on both checklists in order to take into account an element of progression. For administrative purposes a number in brackets was added to these concepts and skills. For example, the definition for direction (1) was "Does the route start at the school gate and finish in the junior playground?" (Breaks in continuity accepted). The definition for direction (2) was "Does the route start at the school gate and finish in the junior playground?" (Breaks in continuity not accepted). Although the definition for direction (3) was identical to direction (2) other criteria were taken into consideration. For example, the drawn cognitive map representation should resemble a large scale Ordnance Survey map of the same area and include more than the twelve cartographic features mentioned earlier, in order to show an element of progression. Figure 2.2 is an example of the checklist constructed as part of the instrument to be used to record the cartographic concepts depicted on children's drawn cognitive map representations.

Figure 2.2

CHECKLIST FOR CARTOGRAPHIC CONCEPTS

Child number ____ Sex ____ Year group ____ Area ______ School

Type of Cartographic concepts identified on the children's drawn cognitive map representations	**Number of concepts identified**
EMERGENT STAGE	
TOPOLOGICAL STAGE route shown (1)	
PROJECTIVE ONE STAGE roads, paths, or pavements shown (1) Sufficient detail. (1) Direction. (1) Orientation. (1) Perspective. (1)	
PROJECTIVE TWO STAGE Plan form. (1) Sufficient detail. (2) Perspective. (2) Continuity of routes. (2) Continuity of roads (2) Improvement in direction. 2) Improvement in orientation. (2) Distance. (1) Scale (1).	
EUCLIDEAN STAGE A true map. Sufficient detail (3) Direction (3) Orientation (3) Distance (2) Scale (2) Shape Size Key. Does the map contain either a key, or are all features labelled?	
TOTAL	

Verbal directional responses

Boardman (1990 p59) suggested that "there is always a possibility that children may know far more about their spatial environment than they are actually able to draw on paper" Therefore the purpose for the construction of the checklist relating to verbal directional responses (Figure 2.3) was to record the extent of children's directional vocabulary. Verbal responses relating to the direction of the route drawn by the children on their cognitive map representations were explicit and posed no interpretation or recording problem. The construction of the checklist was based on Harrison et al's (1989 p20) suggestions that there are four stages of progression starting with directional language such as 'near and far', 'left and right', progressing to full cardinal points, intermediate cardinal points and finally bearings.

For the purpose of recording verbal directional responses, five categories were included in the construction of the checklist (Figure 2.3). The first category termed "relevant language" was to record responses such as "go that way" and "then you're there". The second category, termed "directional language" was to record responses such as "turn", "left" and "right". The third category was concerned with full cardinal points, such as "north" and "south". The fourth category was concerned with intermediate cardinal point responses such as "south-west" etc. Finally, the fifth category was concerned with bearings to record responses such "90 degrees". Although it was considered unlikely those children would use bearings in conjunction with their cognitive map representations, whether drawn or verbal, this stage was included in the checklist in order to accommodate all possibilities. Figure 2.3 shows an example of the constructed checklist for this purpose.

Figure 2.3

CHECKLIST FOR RECORDING VERBAL DIRECTIONAL RESPONSES

Child number Sex ____ Year group____ Area School

	Total
1. Relevant language a/cross, ahead, along, a/round, back, down, follow, go/goes/gets/going, here, in/into, on, over, out, passed, start, stay, stop, straight, there, through, under, up, way,	
2. Directional language left, right, forwards/towards, backwards, sideward, turn,	
3. Full cardinal points North, South, East, West	
4. Intermediate cardinal points NW, NE, SW, SE.	
5. Bearings 0-360 degrees	
Total	

Cartographic Features

The construction of a checklist to record cartographic features such as roads, buildings and fields depicted on children's drawn cognitive map representations was based on Lynch's (1960) five major organizational elements (see previous chapter). He suggested that cartographic features could be grouped into:

Paths such as pavements, roads and trails etc.

Nodes such as important points or places where people can walk through. For example, a crossroad or a road junction a station or church etc.

Landmarks such as conspicuous objects or buildings

Areas or Districts that are recognizable as having some common identifying features such as housing estates, docks, shopping centres etc.

Edges that are boundaries or barriers, such as rivers, canals, railway lines etc.

Lynch's (1960) method of using five major organizational elements provided an objective method of recording the cartographic features depicted on drawn cognitive map representations and was used to construct the checklist for recording purposes (Figure 2.4 column 1). This method was also used to record children's responses relating to the environmental perception; large-scale Ordnance Survey map and vertical aerial photograph variables.

Environmental Perception

Environmental perception is important element in the cognitive map representation process, because it is concerned not only with "What is there?" and "Why it is there?" but also because it gives an insight into the way children feel about and value the places in which they live out their daily lives (Siegel 1982). In order to elicit this affective element of information relating to the drawn cognitive map representations, one-to-one discussions between the researcher and the children need to take place. In some instances, the children will have drawn features, and should be given the opportunity to explain their feelings about what they have drawn. In other instances, children may not have included certain features, but they know that these features play an important part in their daily lives. Figure 2.4 (columns 2, 3, 4 and 5) was constructed as a checklist in order to record the verbal responses relating to environmental perception.

Figure 2.4

CHECKLIST FOR RECORDING CHILDREN'S RESPONSES INTO LYNCH'S (ADAPTED) MAJOR ORGANISATIONAL ELEMENTS

Child number____Sex____ Year group____ Area ________ School

Variables (see below)	1	2	3	4	5	6	7
PATHS 1. bridges /tunnels 2 roads/paths/pavements/trails. 3. dual carriageways 4. motorways							
NODES 5. major road sections 6. churches 7. fire stations 8. railway stations 9. bus stations 10. police stations 11. hospitals							
LANDMARKS 12. Melling School/ own house 12a Melling School grounds 13. Deyes Lane School/ Baths 14. Children's World/ McDonald's							
AREA/DISTRICT 15. houses 16. gardens 17. garages 18. surgeries 19. shops 20. fast food 21. clinics 22. libraries 23. other schools 24. club buildings other buildings							
EDGES 25. rivers/streams/ canals 27. farmland/parkland/fields 28. railway lines other							
OTHER							
TOTAL							

Variables: -

1.Features depicted on children's drawn cognitive map representations

2,3,4 & 5 Environmental Perception (Verbal responses). 2. likes. 3. reasons for likes. 4. dislikes. 5. reasons for dislikes.

6. Verbal identification of features displayed on large-scale Ordnance Survey maps.

7. Verbal identification of features displayed on vertical aerial photographs.

Large Scale Ordnance Survey Map and Vertical Aerial Photograph

Only correct identification of features on large scale Ordnance Survey maps and vertical aerial photographs were recorded. Blaut et al. (1970) suggested that the response be scored as positive if the child pointed to and named the feature correctly. In their study a vertical aerial photograph was shown and each child was asked, "Tell me everything you can see in this picture?" When the child responded with the name of a feature - the experimenter said, "Point to it". This method was replicated in the development of this instrument for both the variables of large scale Ordnance Survey maps and vertical aerial photographs. The children's correct responses were recorded on the checklist (Figure 2.4 columns 6 and 7) as part of the instrument. The literature review provided both the rationale and starting point for the development of the checklists mentioned above and the following procedure involving instructions to the children in order to illicit a wide as possible coverage of their knowledge and understanding of the general mapping variables involved in this research.

THE METHODOLOGY

The Pilot Study

The Initial Development of the Procedure

The second element to be addressed in the development of the instrument was the procedure to be followed in order to elicit children's responses to the general mapping ability variables previously addressed in the construction of the checklists. Two examples of research, using different techniques, were explored and used to underpin the rationale in the initial construction of the instrument. Piaget et al. (1960) studied the way children between the ages of four and ten years of age described a familiar walk. The research was designed to find out the extent of the children's local knowledge and sense of direction. The children's first task was to construct model maps in sand trays, but as discussed in the previous chapter, model maps are used as an alternative method to the drawn cognitive map representation. For the purpose of this research model maps were not used because drawn cognitive map representations were considered to be more easily managed for administrative purposes. Piaget's second task for the children in his test was to draw either a plan in the sand, or on a piece of paper and their responses were used to describe the different developmental stages relating to his theory of Euclidean space.

Matthews (1985a) research involving six to eleven year old children compared four different techniques, namely, the drawn cognitive map representation, vertical aerial photograph and large-scale Ordnance Survey map interpretation and verbal reporting. One technique was carried out in each of four different schools. Both Piaget's and Matthews' research were concerned with the cognitive domain, but the variable of environmental perception was also considered in the development of the instrument because some places are identified by feeling rather than by objective features (Golledge 1999).

Two different familiar areas were tested, because as Piaget (1971) argued, to test children in one familiar area was not sufficient to obtain a true measure of general mapping ability, because children think differently about different areas (Piaget 1971: Matthews 1985a). Most research suggested that the areas around the children's homes and from their homes to school were familiar areas. However, using the home to school area would give some children an unfair advantage, because some children may live near to the school, while others may live up to three miles away. It might be expected that children living further away from the school had the opportunity to identify more cartographic concepts and features on their drawn cognitive map representations. On the other hand, the children living further away from the school and travelling by car, and only following the route in a passive manner could be at a disadvantage, because the children closer to the school, may be walking or cycling and following the route in an active manner. Therefore, in order to ensure the instrument was generalisable to the population, the school perimeter route was used as one of the familiar areas. The other familiar area being a route covering a distance of approximately three miles that was known and used by the children.

The initial instruction was to ask the children taking part in the pilot study to construct two drawn cognitive map representations (one of the school and its perimeter and one of another familiar area approximately two to three miles away). The other familiar area involved the coach route from the pilot study school to the swimming pool used by the children for their swimming lessons. However a problem was highlighted during the initial discussion with the children, because the younger group of children (Reception, Year groups 1 and 2) had not yet started swimming lessons. Therefore the coach route was not a 'familiar area' to these children. However, all of these children had visited Children's World and McDonald's, approximately three miles away and situated on a retail park. The route from their homes to the Retail Park was used for their other familiar area for the younger group of children and the coach route from the school to the swimming pool was retained for the older group of children.

The drawn cognitive map representations were constructed on A3 sized paper, using a black inked pen. There were two reasons for using black inked pens, the first being that they give a distinct print, and enabled the production of clear and readable photocopying for administrative purposes. The other reason being that using pens instead of pencils ensured that the correct cartographic tools were used ensuring an element of good cartography. As Bruner (1969) argued: -

> that intellectual activity anywhere is the same, whether at the frontier of knowledge or in a third grade classroom. The difference is in the degree, not in kind. The schoolboy learning physics is a physicist and it is easier for him to learn physics behaving like a physicist than doing something else.
>
> (Bruner, 1969, p.14)

<u>The first stage of the procedure: Instructions to the pilot study children</u>

The children were divided into two age groups, one group comprising the reception, Year 1 and Year 2 groups of children, and the other group comprising Year 3, 4, 5 and 6 groups of children. An informal discussion was undertaken to enable the researcher and children to become familiar with each other. Although this was a familiarisation session, two questions asked of the children were vital concepts in general mapping and it was important, that the children understood what was being asked of them. The following words were used by the researcher: -

"I want you to help me"

"I want you to draw a map for me"

"But do you know what a map is used for?"

Although the children's responses were not recorded or followed up in the data collection, some of the children's responses relating to the question, "What is a map?" were: "It's a book", It's an atlas" and "A map is a plan of roads and motorways". Examples of responses relating to the question, "What is it used for?" were: "My Dad uses it in the car", "It shows you the way if you get lost" and "It tells you were you are".

One-to-one discussions with the younger group of children and a group discussion with the older children took place. The younger children being told: -

"Now we are going to play a game."

Each child was shown a side-view photograph, a vertical aerial photograph, and a section of a 1:1250 Ordnance Survey map, of the pilot study school and its perimeter. (Figure 1.2)

"Put your hand on the piece of paper that is the map"

If a child gave an incorrect response, the child was told what was depicted on that particular piece of paper. The instructions were repeated until the correct response was given. After each of the younger groups of children had taken part in this task, a brief period of recapitulation took place, concerning their understanding of a map. (The instructions for the older group of children were similar, but carried out within a group activity). The researcher continued the instructions using the following words:

> " Now I am going to tell you a story, but I want to show you a picture first. (They were shown an outline drawing of Mickey Mouse). Do you know who this is? Yes it's Mickey Mouse. Now I will tell you the story. One morning Mickey mouse was standing by the main school gate. He wants to go to the Head teacher's office, but he doesn't know the way. Can you help him? The problem is, he is not allowed to go through the main school gate into the school grounds. He has to start outside the main school gates and walk along the pavement next to the school railings until he gets to the old gates. He needs to go through the old school gate and into the junior playground. Mickey Mouse will need to 'line up' with the children when the bell goes, and one of the teachers will take Mickey Mouse to the Head-teacher. "

The younger group of children were taken into the playground and shown the route and features mentioned in the story. The main school gate and the junior playground were highlighted, because they were the starting and finishing points of the route mentioned in the instructions. This was to ensure that they understood what was being asked of them (Donaldson 1978). The children were taken back into a classroom, and asked to draw a map for Mickey Mouse. They were told that if they made a mistake they could have another piece of paper and start again, but they could not join pieces of paper together. The instructions to the children were:

"I want you to draw a map for Mickey Mouse. He will need to see lots of things on your map"

It was pointed out to the children that the 'maps' drawn by them were unique to them as individuals and there was no question of their maps being 'wrong'. Their maps would all be different, but would all be 'right'. The children were told that their maps should contain all they know and remember about the features they see and go past, including features they cannot see but they know they are there. It was important to extract as much place knowledge and general mapping concepts as possible from the children. The 'Story', contained the information they required, but they were only given minimum cartographic instructions. They were told they must draw certain features on their maps, such as the school, the school gate, the railings, pavement and junior playground on their maps. The children were reminded that Mickey Mouse would like to see lots of things on their maps, because he wanted to use their maps to find his way.

After the children had constructed their drawn cognitive map representation they were given a red pen and told:

"I want you to draw arrows (or a line, if you can't draw arrows) showing the route (or the way) from the main school gate, along the pavement, through the old gate and into the junior playground where you 'line-up' when the bell goes".

The younger group of children drew their 'route' during the 'one-to-one discussions', again to ensure they understood what was being asked of them. The older groups of children were given explicit instructions before they drew their route as part of a group activity. The children were asked to:

"Look at your map again. Look at everything that you have drawn. Have you remembered anything else? You can use your black pen and draw it on your map " and

"Mickey Mouse wants to know "What's this place like?" Have you drawn anything on your map that would make Mickey Mouse feel happy, sad, or scared? " "Do you know what I mean? Let me show you some pictures."

The children were shown two photographs and encouraged to talk about them. One of the photographs showed an area of dereliction close to the school and familiar to the children. The other photograph showed the same derelict land, but reclaimed and used for growing wildflowers. This discussion took part within 'one to one discussion with the infant group of children, and as a group discussion with the junior children. The aim of showing the visual aids was to emphasise that when constructing drawn cognitive map representations, we think about certain features in both a cognitive and affective way. When thinking about familiar areas, we not only think about what is there, but also, how we feel about these places. It is an important element in children's cognitive map representations. (Downs and Stea 1973; Siegel 1982, Golledge 1999). The children were told:

"Look at everything that you have drawn. Mickey Mouse wants to know "What's this place like?" Use the green pen and draw happy faces and unhappy faces next to some of the things that you have drawn on your map that makes you feel happy, sad or angry".

The second stage

This stage was concerned with verbal responses relating to the children's drawn cognitive map representations during 'one to one discussions'. As well as the children understanding what was being asked of them (Donaldson 1978), it was equally important for the researcher to understand the children's interpretation of their maps. No matter how explicit a feature looked on the drawn cognitive map representations, the researcher touched each feature and the child was asked, "What is this"? The aim was to objectively identify all features depicted by the children (including spaces if these appear relevant) and to record this information. For administrative purposes it was convenient to number every feature and record the children's verbal responses on their drawn cognitive map representations.

In order to elicit verbal directional responses the children were told:

> "Put your finger on the red arrow (or line) on your map by the main school gate and follow the route that you have drawn with the red pen. Pretend to tell Mickey Mouse the directions of the route from the main school gate to where you line up in the playground when the bell goes"

The children's verbal directional responses were recorded on the checklist (Figure 2.3) and displayed on their drawn cognitive map representations. In order to elicit responses relating to environmental perception the children were asked:

> "Now tell Mickey Mouse about your happy faces. What do you like? Why do you like it/them? Now tell Mickey Mouse about your sad faces, What do you not like? Why don't you like it/them?"

Their responses were recorded on Figure 2.4 (columns 2, 3, 4 and 5) and displayed on their drawn cognitive map representations. The younger group of children drew their 'happy/unhappy faces' during the 'one to one' discussion with the researcher. The older group of children drew their 'happy/unhappy faces' during group work.

<u>The third stage</u>

The information on the drawn cognitive map representations (both drawn and verbal) does not address all of the variables contained within the umbrella term of cognitive map representations. Children's cognitive map representations can also be elicited through the use of large scale Ordnance Survey maps and vertical aerial photographs. Therefore it was necessary to include the identification of features of a vertical aerial photograph, approximately the same scale and section of a large scale (1:1250) Ordnance Survey map, both relating to the school and its perimeter. The children were asked:

> "Tell me what you can see on this photograph?" and "Tell me what you can see on this map?"

Only correct responses were recorded on Figure 2.4 (columns 6 and 7)

Similar procedures were followed for the children's other drawn cognitive map representation (either the route to the swimming pool for the older group or the route to McDonald's for the younger group of children). Two different routes were used because it was only discovered after carrying out the testing with the older group of children that the younger group of children did not have school swimming lessons and therefore not a familiar area to them.

Both areas involved a route of approximately three miles distance that could only be undertaken using some form of transport. The younger group of children were told a story involving a route starting from their own homes and finished at McDonald's. They were told that they had been invited to a birthday party at McDonald's, but first they had to go to Children's World to buy a present. The older groups of children were told a story involving a route that started at the school gate and finished at the swimming pool. They were told that the coach driver taking them to the swimming pool did not know the way and needed a map.

The interpretation and evaluation of the pilot study and modification to the instrument is addressed in the following section of this chapter.

THE METHODOLOGY

Findings of the pilot study and evaluation

The instructions and 'story part' of the instrument showed that two modifications were required. The first modification was to include additional instructions involved in the direct experience for the younger group of children. This group of children had not attended the school for as long as the older group of children and this fact may have placed them at a disadvantage. They would not have been as familiar with some of the cartographic features mentioned in the story and instructions relating to Map Area A (the school area).

The initial instructions included taking the children into the playground after the story had been told and shown the features mentioned in the story. In retrospect, both walking around the route and showing the features should have been undertaken. Although the main school gate and the junior playground were highlighted because they were the starting and finishing points of the route mentioned in the instructions, other features should have been pointed out to the children during the walking of the route. The instructions were modified to include the following direct experience: -

The younger group of children should be asked to stand in the infant playground and face the school building. They would be asked what they could see and told to remember what they had seen. Then they would be told to look towards the car park (this was a 90 degree turn) and asked what they could see and again told to remember what they had seen. This instruction would be repeated with two more 90-degree turns, thus giving the children the opportunity to see all possible cartographic features. The modified instructions were undertaken firstly, in order to maximise the quality of their maps without the children being given didactic teaching. The second modification was to include both additional and more explicit instructions to the children prior to the construction of their drawn cognitive map representations. For example, the younger group of children should be told, "Do you remember when we went for our Mickey Mouse walk? Do you remember when we turned around in the playground and looked at everything? Can you remember all the things you saw? Will you draw all the things that you have remembered on your map?" The older group of children should be asked to pretend that they were standing by the main school gate (where the cars go through to get into the car park). They were told to pretend to face the houses on the other side of the road and asked what would they be able to see. They were then told to pretend to turn right, and again asked what they would be able to see. This instruction was repeated until 360 degrees had been turned. They were told that all features remembered by them could be drawn on their maps.

There were two main implicit issues at stake; firstly, it was important that a lack of observation should not hinder the quality of the children's drawn cognitive map representations. Secondly, it was important to ensure that the children understood what was being asked of them in the way that the researcher meant them to be understood (Donaldson 1978).

One of the disadvantages was that the different children completed their drawn cognitive map representations at different times. This was remedied by exchanging the completed drawn cognitive map representations for a Mickey Mouse picture (to colour in), until all children were ready for the next stage.

The time factor was important, especially during the testing of the school area, when it was found that if the testing was not completed during one teaching session, the children who had completed their maps were at a disadvantage. The other children had the opportunity to look at the Mickey Mouse route again during their 'playground break' and possibly add more features to their maps. The main testing relating to the construction of the drawn cognitive map representations would be contained within two teaching sessions, one for the school area and one for the other area.

The importance of 'one-to-one' discussions between the researcher and children was highlighted during the stage relating to the verbal identification of features on their drawn cognitive map representations. As well as the children understanding what was being asked of them (Donaldson 1978), it was equally important for the researcher to understand the children's interpretation of their maps. For example, Figure 2.5 shows

Anne's drawn cognitive map representation relating to the school area and feature number eight, which looks like a row of terraced houses in plan form. However, according to Anne, it was 'the railings'. Another example highlighting the importance of the 'one to one' discussions is Figure 2.6, showing Andrea's drawn cognitive map representation. Three identical features (numbered 2), in reality do not exist. According to Andrea, these were the spaces where the children 'lined up' when the bell went. Feature number 7, was the shape of the school roof, but unless verbally identified by the Andrea, it would have been difficult for the researcher to name this feature. Number 8 looks as though it was drawn in error, but it was identified by Andrea as 'grass'. Finally, number 4 was confidently, but mistakenly identified by the researcher as a road, but it was only the space between two drawn features.

A touching and talking element in the 'one to one' discussion was shown to be equally important when addressing the variables of large scale Ordnance Survey maps and vertical aerial photographs. For example, when shown a vertical aerial photograph and asked to identify known features, one child gave the answer of "motorway". There was a motorway on the vertical aerial photograph, but when asking the child to touch the motorway, he touched the canal instead. This example again, reiterates the importance of ensuring that the researcher understands what is in the children's mind (Donaldson 1978).

The recording of children's responses on the checklists using Lynch's (1960) five major organisational elements showed that two modifications were required. Some of the features depicted on children's drawn cognitive map representations could not be placed into any of Lynch's organisational elements. For example, features such as "the steps, the chimney, the bus stop, the balloons, McDonald's logo and hopscotch" (Figures 2.7, 2.8, 2.9, 2.10, 2.11, and 2.12) play an important role in the affective domain of children's cognitive map representations (Siegel 1982). In order to record these features, another organisational element was included and given the term of "discrete features".

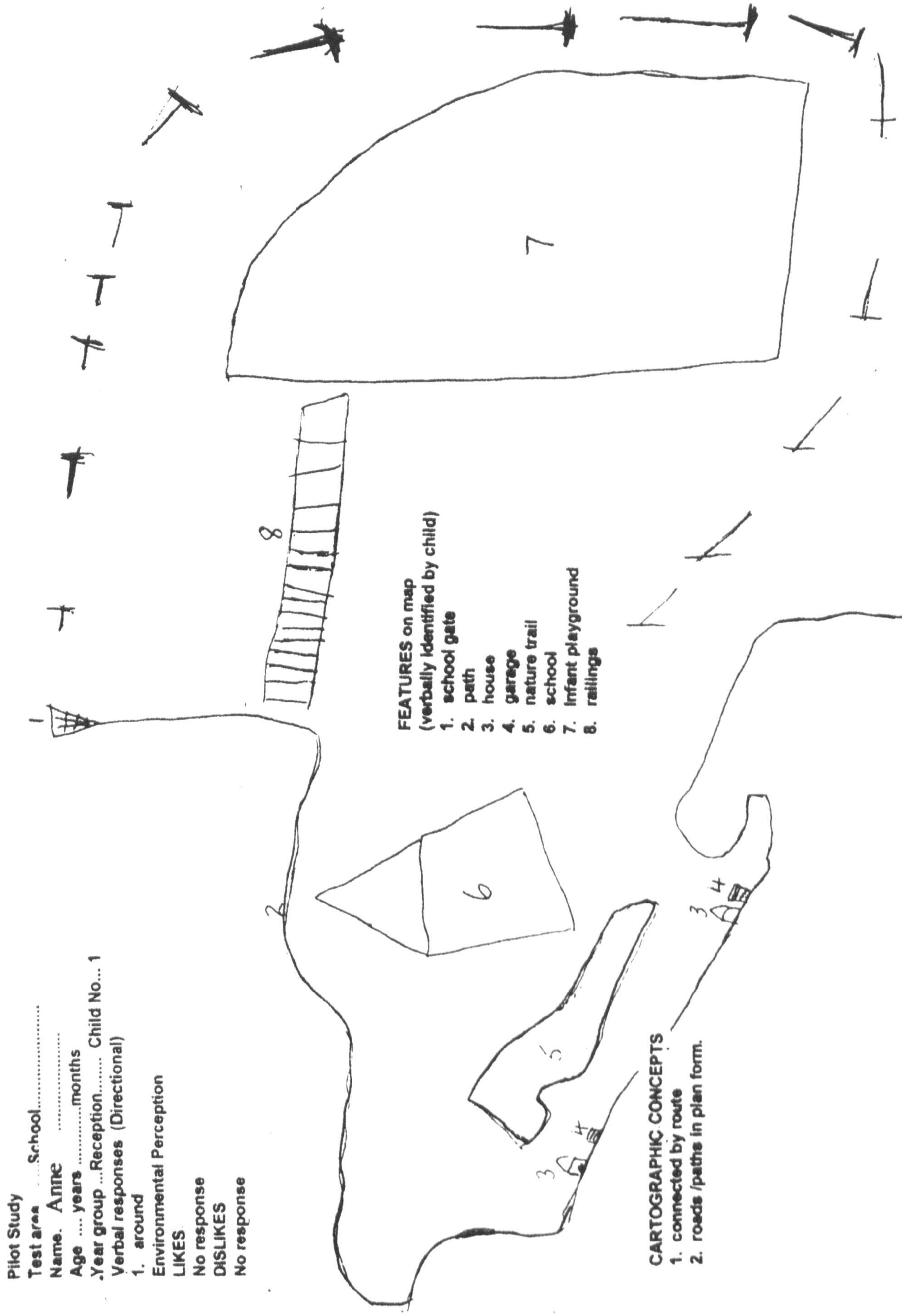


Figure 2.5 Drawn cognitive map representation of Map area A by Anne (reception)

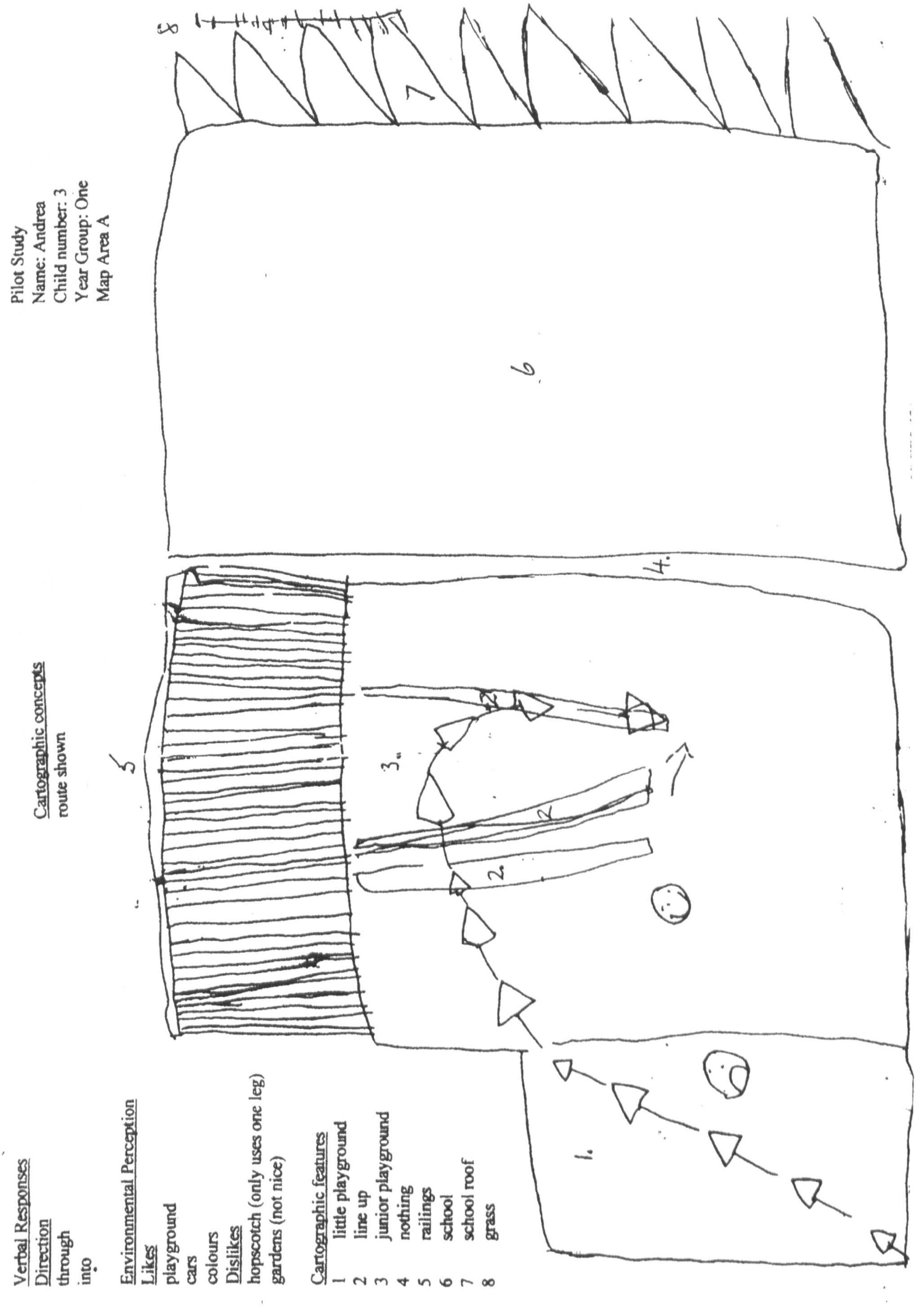


Figure 2.6 Drawn cognitive map representation of Map area A by Andrea (Year 1)

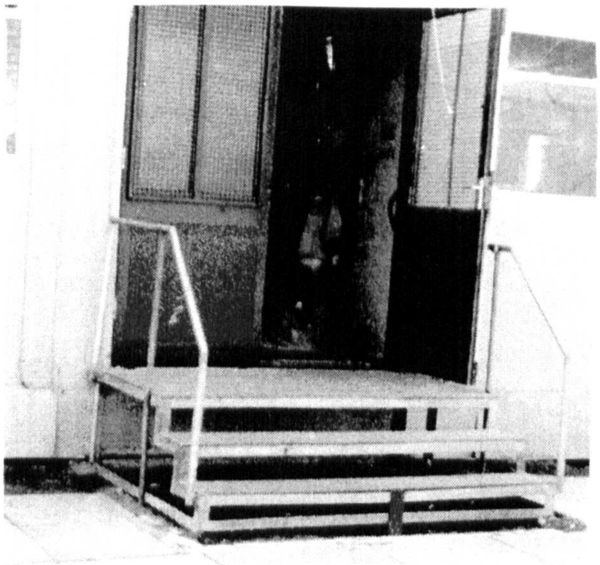


Figure 2.7 The Steps

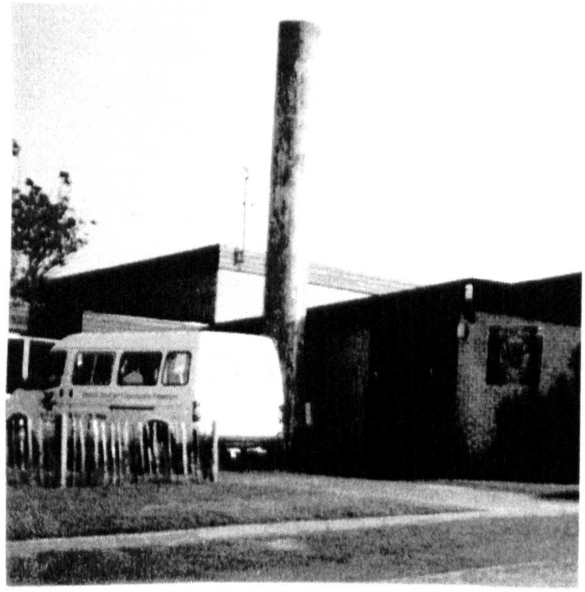


Figure 2.8 The Chimney

Figure 2.9 The Bus Stop

Figure 2.10 The Balloons

Figure 2.11 McDonald's Logo

Figure 2.12 The Hopscotch

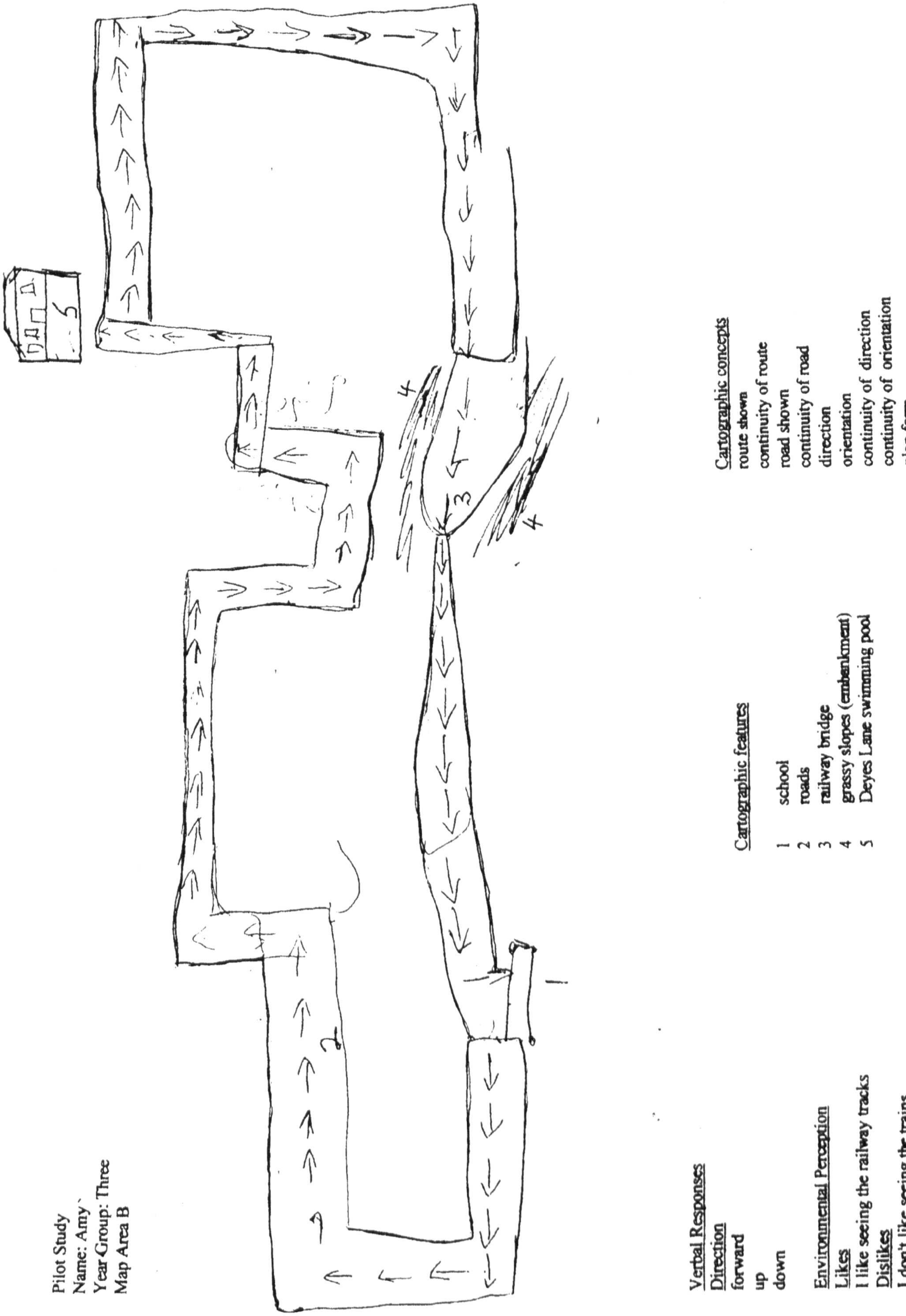


Figure 2.13 Drawn cognitive map representation of Map area A by Amy (Year 3)

Another organisational element was also included and given the term " Ordnance Survey maps", because the names of roads and places; house numbering, railway embankments etc. can be identified on large scale Ordnance maps, they are not included within Lynch's (1960) five organisational elements. Figure 2.13 shows Amy's drawn cognitive map representation and feature number 4 shows grassy slopes (railway embankments) on either side of the railway bridge.

INSTRUCTIONS FOR COMPLETING THE CHECKLISTS

On completion of the children's cognitive map representations, all responses, both drawn and verbal, were recorded visually on the children's drawn cognitive map representations. Figure 2.14 shows one of the children's drawn cognitive map representations relating to the school area. The example was constructed by Brian, a Year group four boy and was used to illustrate how his cognitive map representations were interpreted, scored and recorded by addressing and completing the appropriate checklists.

Checklist relating to drawn cognitive map representation developmental stages

The following three items were required: -

1. Brian's drawn cognitive map representation of the school area (Figure 2.14)

2. part of a large scale (1:1250) Ordnance Survey map showing the route mentioned in the instructions (Figure 2.15)

3. the checklist (and instructions) outlining the interpretation of children's drawn cognitive map representations and placing them into cognitive map developmental stages (Figure 2.16)

To make the interpretation and scoring as objective as possible, the questions on the checklist produced 'Yes' or 'No' answers. By looking at the features drawn by Ben and the two lists under the headings of 'Cartographic features' and 'Cartographic concepts' on his drawn cognitive map representation (Figure 2.14) it was possible to answer most of the questions on the checklist (Figure 2.16). However, some of the questions could not have been answered without referring to the large-scale Ordnance Survey map (Figure 2.15). For example, to be able to answer question four

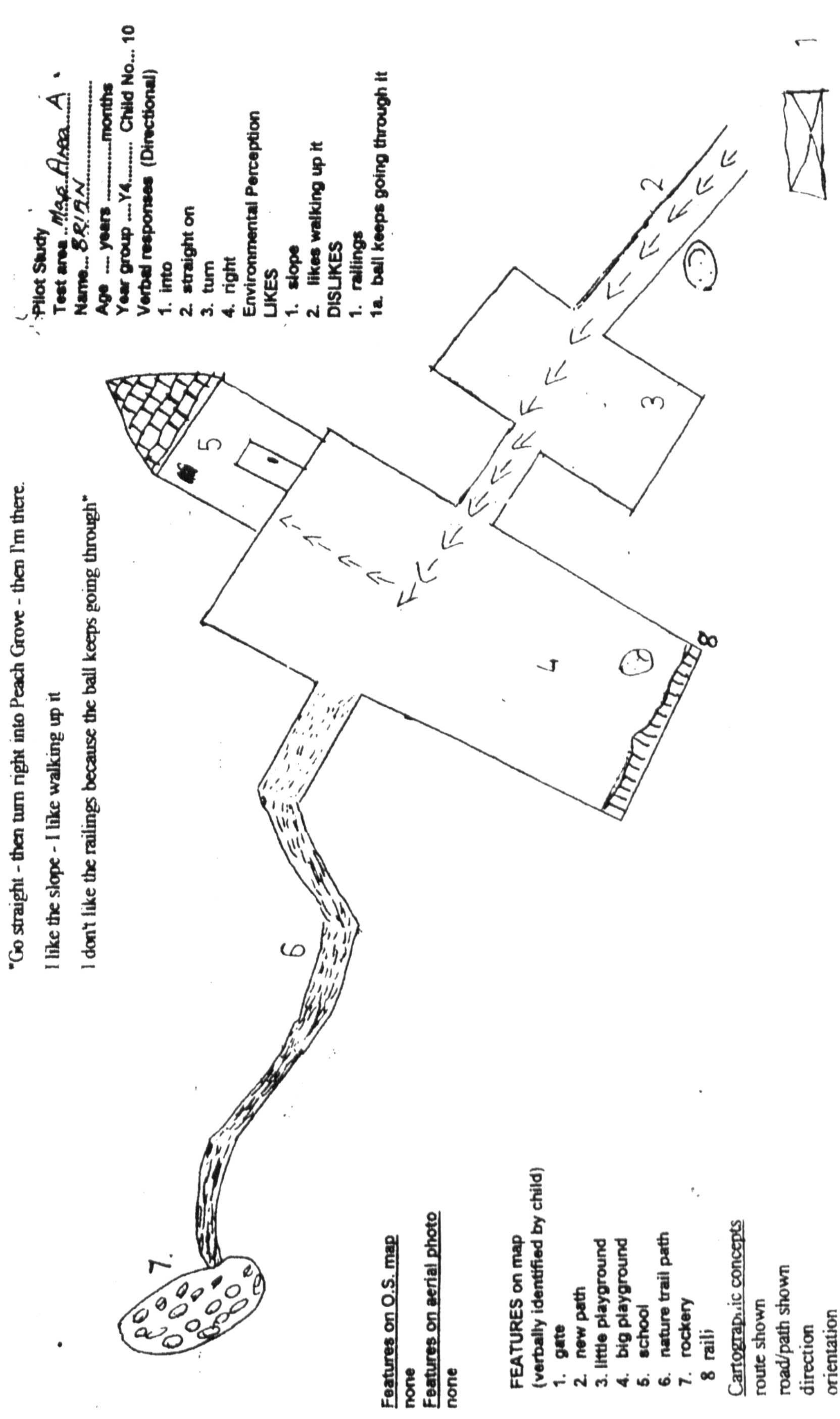


Figure 2.14 Drawn cognitive map representation of Map area A by Brian (Year 4)

School 1

A section of a 1:1250 Ordnance Survey map showing the route (mentioned in the instructions to the children) from the main gate to the junior playground

KEY

A	School field
B	Infant playground
C	Junior playground
D	Nature trail

Figure 2.15 Large-scale Ordnance Survey map showing Map area A (School 1)

at projective stage one on the checklist relating to developing stages of drawn cognitive map representation (Figure 2.16), it was necessary to compare Brian's drawn cognitive map representation with the Ordnance Survey map (Figure 2.15), showing the route mentioned in the instructions. Brian did not understand the concept of perspective, because he did not draw any features that he could not see if he walked the route mentioned in the instructions.

Brian only partially followed the researcher's instructions, as can be seen from Figures 2.14 and 2.15, His route started at the school gate (see number 1 on the cartographic concepts and list on his map - see Figure 2.14), but instead of his route following the perimeter of the school along the road or pavement, his route followed a school path, through the infant playground, before finishing in the junior playground. Because his route started at the school gate he understood the concept of route at the topological stage. He also understood the concepts of road, direction and orientation at the projective one stage, because he depicted a path showing a route on his drawn cognitive map representation, which started and finished at the correct places, even though his route was different from the route mentioned in the instructions. The checklist relating to stages of development (Figure 2.16) includes five concepts at the projective one stage. Although Brian did not include sufficient features nor understand the concept of perspective, the completed checklist (Figure 2.16) showed that Brian was placed at the projective one stage of development. He was placed at this stage because he understood at least one of the concepts placed within the projective one stage, but none of the projective two concepts. The question of stages of development is discussed in more detail in the following chapter.

Checklist relating to cartographic concepts

The following three items were required: -

1. Brian's drawn cognitive map representation of the school area (Figure 2.14)
2. the checklist (and instructions) outlining the interpretation of children's drawn cognitive map representations and placing them into cognitive map developmental stages (Figure 2.16)
3. Checklist for cartographic concepts (Figure 2.17).

Figure 2.16

CHECKLIST (AND INSTRUCTIONS) OUTLINING THE INTERPRETATION OF CHILDREN'S DRAWN COGNITIVE MAP REPRESENTATIONS AND PLACING THEM INTO STAGES OF DEVELOPMENT

PILOT STUDY

Child number 10 (Brian) Sex M Year group 4 Map Area A

EMERGENT STAGE Start at the Topological Stage. Does the child fulfil the requirements of the Topological Stage? If the answer is NO, the child is at the Emergent Stage	**YES**/NO
TOPOLOGICAL STAGE Link Picture MAP Does the route (arrow/ line that can be broken) start near the school gate? If answer is NO, the child is at the Emergent stage. If answer is YES, continue to next stage	**YES**/NO
PROJECTIVE ONE STAGE Are any roads or paths or pavements shown, in addition to the route?	**YES**/NO
Sufficient detail. Have at least eight features been identified? (Do not include discrete features)	YES/**NO**
Direction. Does the route (arrow or line) start at the school gate and finish in the junior playground? (Breaks in continuity accepted)	**YES**/NO
Orientation. Does the route (arrow or line) start at the school gate and finish in the junior playground? (Breaks in continuity accepted)	**YES**/NO
Perspective. Look at the OS map showing the route. Are there any features on the child's drawn cognitive map representation that the child cannot visually see, if he she walked the route?	YES/**NO**
PROJECTIVE TWO STAGE Plan form. Are any of the buildings in plan form?	YES/**NO**
Sufficient detail. Have more than eight features been identified on the map? (Do not include discrete features)	YES/**NO**
Perspective. Look at the OS map showing the route. Are there any features on the map that the child cannot see, if he/ she walked the route? Features must be connected by road.	YES/**NO**
Continuity of routes. Does the route (arrow or line) start at the school gate, follow instructions and finish in the junior playground? (breaks in continuity NOT accepted)	YES/**NO**
Continuity of roads Does the road start at the gate and finish near the junior playground gate? (Breaks in continuity NOT accepted)	YES/**NO**
Improvement in direction. Does the route follow the road/path, start the school gate and finish in the junior playground? (Breaks in continuity NOT accepted)	YES/**NO**
Improvement in orientation. Does the route follow the road/path, start the school gate and finish in the junior playground? (Breaks in continuity NOT accepted)	YES/**NO**

Distance. Is the shape of the child's map similar to the route marked on the OS map of the same area?	YES/NO
Scale. Is the shape of the child's map similar to the route marked on the OS map of the same area and are similar features the same size and shape?	YES/NO
EUCLIDEAN STAGE A true map. Is the map in plan form and can it be read and understood completely?	YES/NO
Accurate and detailed. Does the map accurately show more details, than those asked for in the instruction? (At least thirteen features should have been identified. Do not include discrete features)	YES/NO
Does it reasonably resemble the Ordnance Survey map of the area and the researcher's instructions? Are the following concepts roughly accurate and similar to the ORDNANCE SURVEY map of the area?	
Direction	YES/NO
Orientation	YES/NO
Distance	YES/NO
Scale	YES/NO
Shape	YES/NO
Size	YES/NO
Key. Does the map contain either a key, or are all features labelled	YES/NO
PLACING THE CHILD INTO STAGES OF EUCLIDEAN DEVELOPMENT. (Underline the appropriate stage) The "Yes/No" answers on the checklist will explicitly show the relevant stage. If there are some "Yes" answers in over-lapping stages, then the child will be at an over-lapping stage (e.g. Projective One/Projective Two stage) EMERGENT STAGE TOPOLOGICAL STAGE PROJECTIVE ONE STAGE PROJECTIVE TWO STAGE EUCLIDEAN Stage	
CHILDREN'S UNDERSTANDING OF CARTOGRAPHIC CONCEPTS AND SKILLS The "Yes/No" answers on the checklist will explicitly show the child's understanding of the cartographic concepts listed below. If no concepts have been understood, record on map as "Emergent stage." Route shown ✓ / Roads/paths shown ✓ Direction ✓ / Orientation ✓ Perspective / Continuity of routes Buildings in plan form / Continuity of roads Improvement in direction / Improvement in orientation Distance / Scale Shape / Size Key or complete labelling	

The completion of the checklist relating to stages of development (Figure 2.16) automatically identified the following cartographic concepts: -

route shown

roads or paths shown

direction

orientation

These were displayed on Brian's drawn cognitive map representation (Figure 2.14) under the heading 'Cartographic concepts'. This information was transferred to the 'Checklist for cartographic concepts' (Figure 2.17).

Checklist relating to Verbal directional responses

The following three items were required: -

1. Brian's drawn cognitive map representation of the school area (Figure 2.14)
2. part of a large scale (1:1250) Ordnance Survey map showing the route mentioned in the instructions (Figure 2.15)
3. Checklist for Verbal directional responses (Figure 2.18).

Brian's verbal responses relating to the route drawn on his drawn cognitive map representation (Figure 2.14) reiterates the importance of including verbal responses as one of the variables, because the route drawn by Brian was not the same as the route he verbally described. He verbally described the route given by the researcher in the instructions and shown on the large-scale Ordnance survey map (Figure 2.15). This was recorded and shown on Brian's map as, "Go straight - then turn right into Peach Grove – then I'm there". The relevant directional language such as:

go

straight

turn

right

into

there

was transferred to the 'Checklist for Verbal Directional Responses' (Figure 2.18)

Figure 2.17

CHECKLIST FOR CARTOGRAPHIC CONCEPTS

PILOT STUDY

Child number 10 (Brian) Sex M Year group 4 Map Area A

Type of Cartographic concepts identified on the children's drawn cognitive map representations	**Number of concepts identified**
EMERGENT STAGE	
TOPOLOGICAL STAGE route shown (1) ✓	1
PROJECTIVE ONE STAGE roads, paths, or pavements shown (1) ✓ Sufficient detail. (1) Direction. (1) ✓ Orientation. (1) ✓ Perspective. (1)	3
PROJECTIVE TWO STAGE Plan form. (1) Sufficient detail. (2) Perspective. (2) Continuity of routes. (2) Continuity of roads (2) Improvement in direction. (2) Improvement in orientation. (2) Distance. (1) Scale (1).	
EUCLIDEAN STAGE A true map. Sufficient detail (3) Direction (3) Orientation (3) Distance (2) Scale (2) Shape Size Key. Does the map contain either a key, or are all features labelled?	
TOTAL	4

Figure 2.18

CHECKLIST FOR RECORDING VERBAL DIRECTIONAL RESPONSES

PILOT STUDY

Child number 10 (Brian) Sex M Year group 4 Map Area A

Verbal directional responses relating to the route drawn by the children on their cognitive map representations.	Total
1. Relevant language a/cross, ahead, along, a/round, back, down, follow, go/goes/gets/going, here, in/into, on, over, out, passed, start, stay, stop, straight, there, through, under, up, way,	4
2. Directional language left, right, forwards/towards, backwards, sidewards, turn	2
3. Full cardinal points North, South, East, West	
4. Intermediate cardinal points NW, NE, SW, SE.	
5. Bearings 0 – 360 degrees	
Total	6

The other variables: -

The construction of one checklist to include the following four variables (Figure 2.19) was based on Lynch's (1960) five major organisational elements:

1. Cartographic features identified on the drawn cognitive map representations
2. Verbal environmental perception responses (relating to likes, dislikes and reasons)
3. Identification of features on large scale Ordnance Survey maps
4. Identification of features on vertical aerial photographs

As mentioned earlier, modifications were made to this checklist in order to include the additional organisational elements of large scale Ordnance Survey maps and discrete features.

Figure 2.19

CHECKLIST FOR RECORDING CHILDREN'S RESPONSES INTO LYNCH'S (ADAPTED) MAJOR ORGANISATIONAL ELEMENTS

Child number 10 Sex M Year group 4 School Area A

Concepts (see below)	1	2	3	4	5	6	7
PATHS 1. bridges /tunnels 2 roads/paths/pavements/trails. 3. dual carriageways 4. motorways	2						
NODES 5. major road sections 6. churches 7. fire stations 8. railway stations 9. bus stations 10. police stations 11. hospitals							
LANDMARKS 12. Own School/ own house 12a Own School grounds 13. Deyes Lane School/Baths 14. Children's World/ McDonald's	1 2						
AREA/DISTRICT 15. houses 16. gardens 17. garages 18. surgeries 19. shops 20. fast food 21. clinics 22. libraries 23. other schools 24. club buildings other buildings							
EDGES 25. rivers/streams/ canals 27. farmland/parkland/fields 28. railway lines other							
OS MAPS (not included above) 29. pond/lake 30. embankments 31. road names 32. house numbers 33 key/title 34 car park 35. compass							
CHILDREN'S DISCRETE FEATURES	3	1	1	1	1		
TOTAL	8	1	1	1	1	0	0

Variables: - 1. features on map. 2. likes .3. reasons. 4. dislikes. 5. reasons 6. features on O.S. map. 7. features on aerial photograph

Checklist relating to Cartographic features

The following items were required: -

1. Brian's drawn cognitive map representation of the school area (Figure 2.14)
2. Checklist relating to cartographic features (Figure 2.19 column 1).

The following features were identified on Brian's drawn cognitive map representation (Figure 2.14): - new path, little playground, big playground, school and nature trail. Brian also included the following discrete features: - gate, rockery and railings.

The above eight features were displayed on Brian's drawn cognitive map representation under the heading 'Cartographic features'. This information was transferred to the Checklist for Cartographic features (Figure 2.19 column 1).

Checklist relating to verbal environmental perception responses

The following two items were required: -

1. Brian's drawn cognitive map representation of the school area (Figure 2.14)
2. Checklist relating to verbal environmental perception responses, (Figure 2.19 columns 2, 3, 4 and 5).

Brian's drawn cognitive map representation shows a 'happy face' (see number 2 on Figure 2.14) placed near the new path. His verbal responses were "I like the slope - I like walking up it." Figure 2.20 shows a photograph of the slope, but Brian positioned it in the wrong place, it should have been placed near the start of the nature trail (see number 6 on Figure 2.14). It needs to be pointed out that this was not an issue, as only verbal environmental perception responses were being considered. Brian's 'unhappy face' (see number 8 on Figure 2.14) was placed near to the railings. Figure 2.21 shows a photograph of the railings. His verbal responses were, "I don't like the railings because the ball keeps going through". The responses were recorded on the drawn cognitive map representation (Figure 2.14) and transferred to the 'Checklist for Verbal Responses' (Figure 2.19 columns 2, 3, 4 and 5), relating to the likes, dislikes and reasons of the two familiar areas.

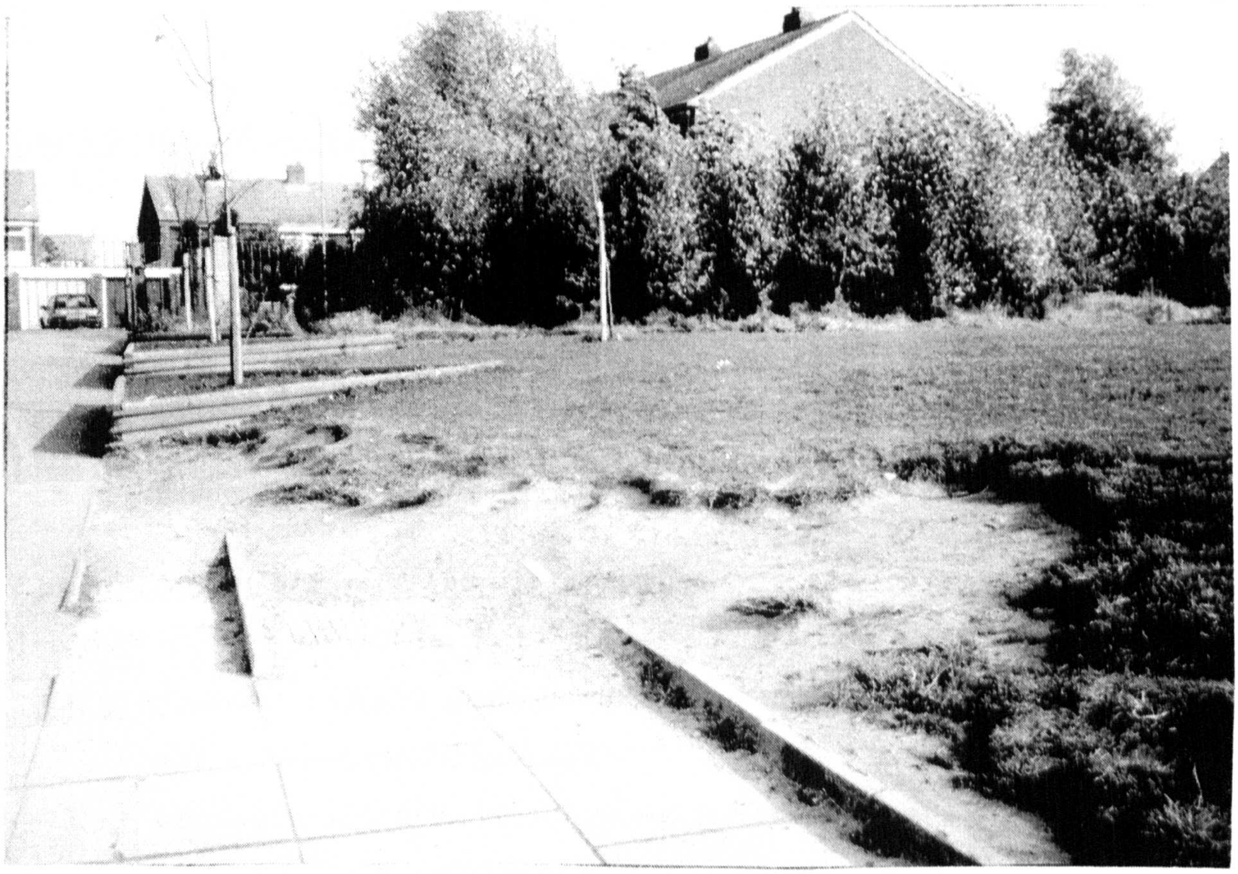


Figure 2.20 shows slope mentioned in Brian's environmental perception responses.
"I like the slope – I like walking up it"

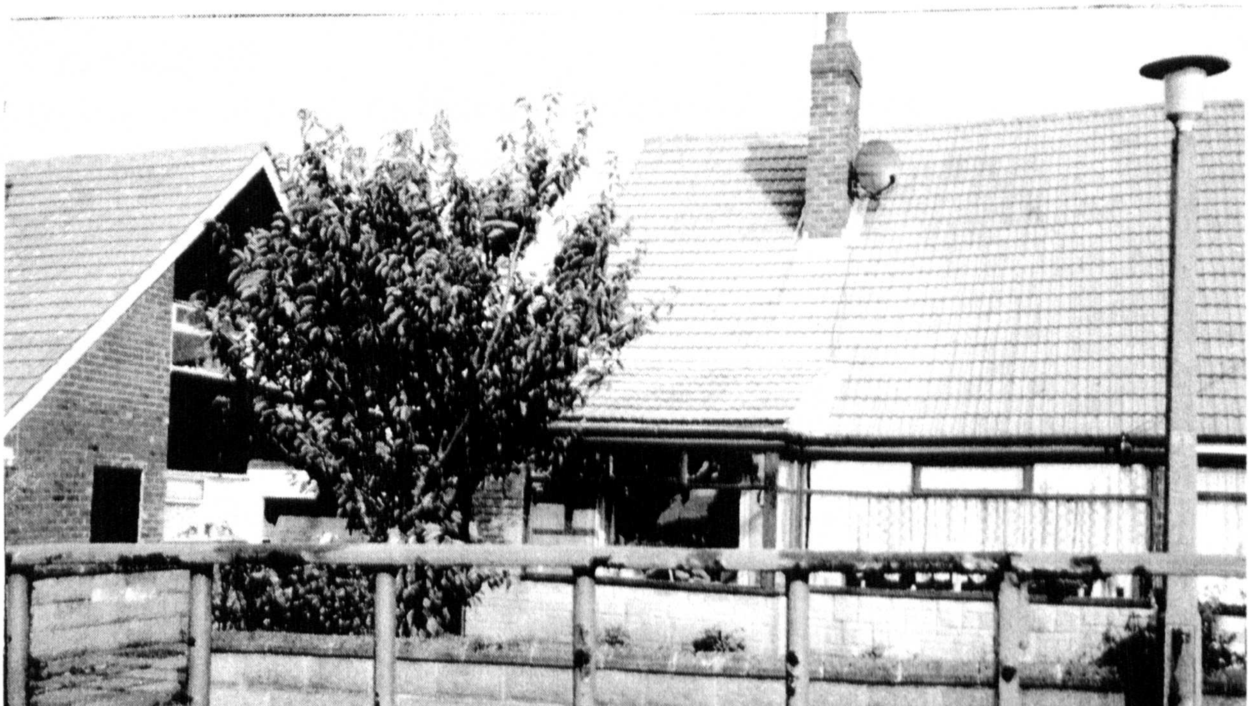


Figure 2.21 shows railings mentioned in Brian's environmental perception responses.
"I don't like the railings because the ball keeps going through"

Checklist relating to an Ordnance Survey map

The following items were required: -

1. part of a large scale (1:1250) Ordnance Survey map showing the route mentioned in the instructions (Figure 2.15)
2. Checklist relating to the identification of features shown on a large scale Ordnance Survey map (verbal responses). (Figure 2.19 column 6).

Brian was unable to identify any features on the Ordnance Survey map.

Checklist relating to a vertical aerial photograph

The following two items were required: -

1. A vertical aerial photograph showing position of School 1 and surrounding geographical features (Figure 2.22)
2. Checklist relating to the identification of features shown on a vertical aerial photograph (verbal responses). (Figure 2.19 column 7).

Brian was unable to identify any features on the vertical aerial photograph

The coded profile

The scoring from Brian's checklists was transferred to a coded profile (Figure 2.23), which placed Brian at the projective one stage of development and showed a quantitative score of twenty-two relating to his overall general mapping ability.

Inter-rater reliability check

An inter-rater reliability check was implemented in order to test the methodology and reliability of the instrument. Although, the instrument, and in particular, the procedures for the construction and scoring of the checklists were made as explicit and objective as possible, it was an important criterion that when the scoring of tests involves subjectivity we are concerned with scorer/rater reliability (Gay 1992). A second scorer (using un-marked checklists) followed the same procedure as outlined in this section, using all fourteen pilot study children's drawn cognitive map representations and verbal responses for both map areas. Figure 2.14 shows one of the children's drawn cognitive map representations and was used as an example to illustrate how it was interpreted, scored and recorded by addressing and completing the appropriate checklists. Comparisons were made and this was evaluated at an inter-rating of 95%. The high rating was possibly due to the tight scoring mechanism of the yes/no answers on the checklist relating to developmental stages and the verbal identification (by the children) of the features depicted on the drawn cognitive map representations. In addition all verbal responses were depicted on the drawn cognitive map representations to ensure explicit transfer to the various checklists.

Figure 2.22 Vertical aerial photograph showing cartographic features surrounding School 1

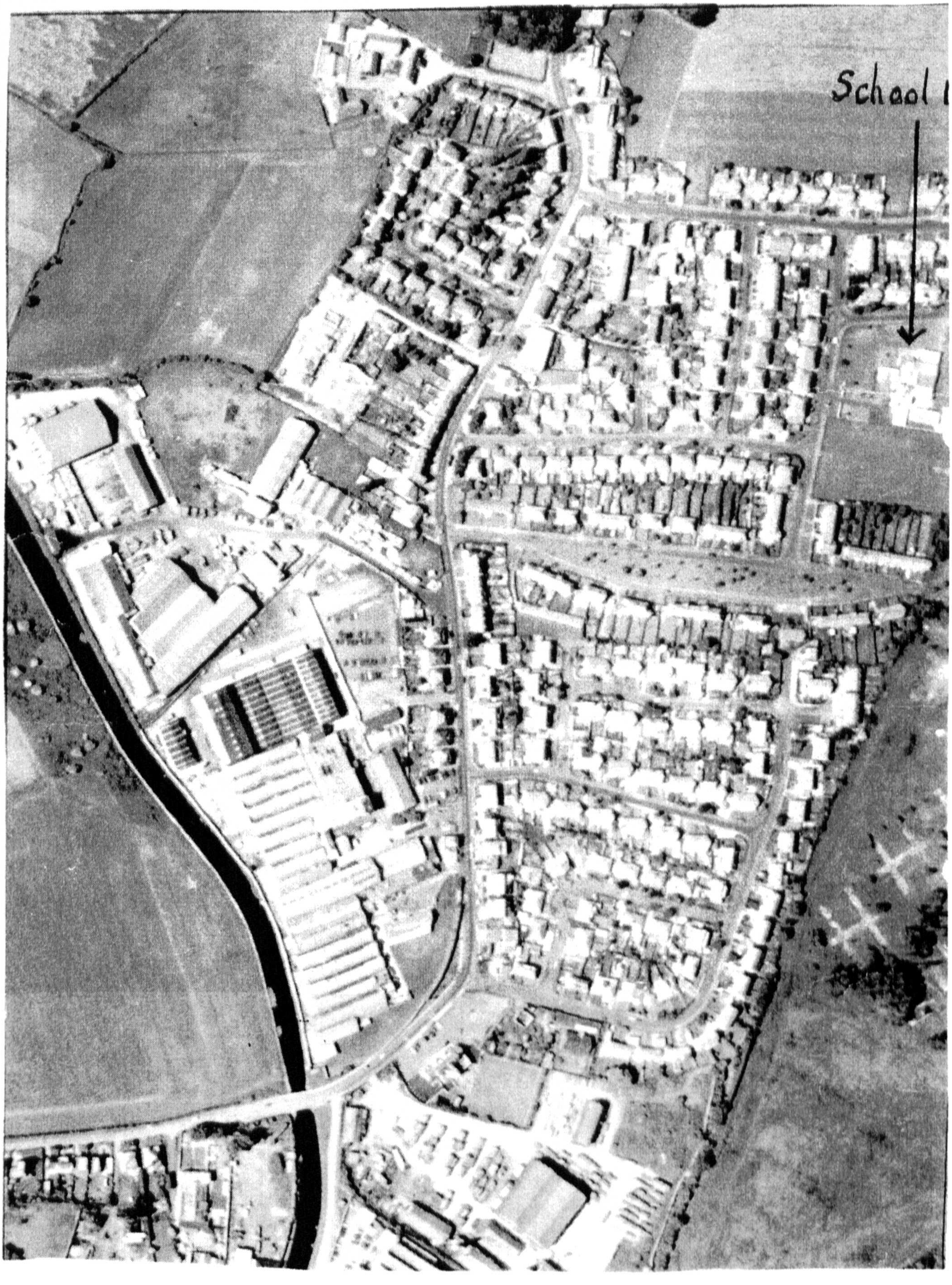


Figure 2.23 Example of completed Coded Profile showing number of responses relating to children's cognitive map representations (drawn and verbal)

Child number 10 Sex M Sch. no. 1 Year group 4 Area MAP A

Cartographical concepts/skills

1. Emergent Stage
2. Topological Stage /
3. Projective One Stage 3
4. Projective Two Stage
5. Euclidean Stage

Features on cognitve map

1. paths 2
2. nodes
3. landmarks 3
4. area/district
5. edges
6. O. S. map
7. discrete features 3

Likes (reasons)

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features /

Dislikes (reasons)

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features /

Features on aerial photographs

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features

Verbal Directions

1. relevant language 4
2. directional language 2
3. full cardinal points
4. intermediate cardinal points
5. bearings

Likes (Environmental Perception)

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features /

Dislikes(Environmental perception)

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features /

Features on O S maps

1. paths
2. nodes
3. landmarks
4. area/district
5. edges
6. O. S. map
7. discrete features

Developing stages of drawn cognitive map representations

1. Emergent Stage
2. Topological Stage
3. Projective One Stage
4. Projective One/Two Stage
5. Projective Two Stage
6. Euclidean Stage

TOTAL RESPONSES = 22

THE METHODOLOGY

Data emerging and tentative issues relating to the pilot study

The previous section showed that children's drawn and verbal cognitive map representations were explicit enough for checklists to be marked objectively, but some modifications were required. Although coded profiles provided the raw data for the construction of tables and graphs, statistical tests of differences were not attempted because it was considered that the sample (fourteen children) was too small. However, from the interpretation of the tables the following observations were made:

Relating to Developmental Stages

Emergent Stage of Development

An emergent stage was included in the development of the pilot study checklist because Wickstead's (1991) research showed that 15% of the drawn cognitive map representations were recorded as "non-scoring". Yet a large percentage of the same children did score in other variables relating to general mapping ability that were not dependent solely upon the ability to draw, such as giving verbal directions. However, the pilot study showed that none of the children's drawn cognitive map representations were placed at the emergent stage. A tentative reason could be that an insufficient number of children took part in the pilot study. But it was possible that by testing different children, this stage could be required within the relevant checklist and therefore retained within the development of the instrument.

Over-lapping stages of development

This observation was concerned with the number of children's drawn cognitive map representations over-lapping between different developmental stages. The pilot study showed that about one fifth of the drawn cognitive map representations could not be placed into a definite developmental stage (as defined by Catling, 1978) when considering Map Area A and about one third when considering Map Area B.

Different stages of development between Map Area A and Map Area B

A number of children were placed at different developmental stages when comparing their drawn cognitive map representations for Map Area A against Map Area B. Piaget (1971 p10) acknowledged this problem for the theory of stages as that of time lags.

Modifications to the checklist relating to Lynch's organisational elements

The Ordnance Survey Map Element

Another organisational element was included on the checklist using Lynch's organisational elements. This element (termed Ordnance Survey maps) was included in order to accommodate features such as the names of roads and places, house numbering and railway embankments. Features such as these can be identified on large scale Ordnance Survey maps, but they were not catered for in any of Lynch's (1960) five organisational elements of paths, nodes, landmarks, area or edges. However, none of the pilot study children displayed any of these features for Map Area A (Table 2.1) and only one child identified an Ordnance Survey map feature relating to Map Area B (Table 2.2). The initial checklist was modified in order to accommodate the larger number of children's drawn cognitive map representations to be included in the main research.

The Discrete Features Element

The pilot study findings showed modifications to the cartographic features checklist were necessary to include the additional organisational element of discrete features in order to accommodate features such as "the sandy slope", "McDonald's logo", "the line-up", "the bus-stop" etc. Features such as these are depicted on children's drawn cognitive map representations but they were not catered for in Lynch's (1960) five organisational elements. Table 2.1 shows 40% of the features depicted on the children's drawn cognitive map representations relating to Map Area A and 14% relating to Map Area B (Table 2.2) were discrete features.

Table 2.1. Number of features depicted on Pilot study children's drawn cognitive mapping representations (Map Area A)

	No.features depicted on drawn representations	**Features shown as a percentage of total**
Paths	29	19.7
Nodes	0	0
Landmarks	37	25.2
Area/District	16	10.9
Edges	6	4.1
Features on O.S.Maps	0	**0**
Discrete Features	59	**40.1**
total number of features	147	100

Table 2.2. Number of features depicted on Pilot study children's drawn cognitive mapping representations (Map Area B)

	No.features depicted on drawn representations	**Features shown as a percentage of total**
Paths	47	28.9
Nodes	6	3.7
Landmarks	37	22.7
Area/District	38	23.3
Edges	11	6.7
Features on O.S.Maps	1	**0.6**
Discrete Features	23	**14.1**
total number of features	163	100

The five observations discussed above caused difficulties in applying the instrument, and it was felt that further exploration was required before the main research was undertaken. Because the sample was small (14 children), it was considered important to test the instrument again using a larger number of children. This is addressed in the next section of this chapter.

THE METHODOLOGY

Follow-up to the pilot study

Five observations emerged during the pilot study that caused difficulties in applying the instrument, and it was considered important that further exploration was required before the main research was undertaken.

The sample and procedure

The seventy-two children (six boys and six girls from each of the primary year groups ranging from reception to year group 5) taking part in the follow-up to the pilot study were from one of three schools taking part in the main research. These children were both part of the population and the stratified sample outlined in the following chapter. The children followed the same instructions and procedures as in the pilot study, but the procedures included modifications. Each child was asked to draw two maps. One map related to the immediate perimeter of the school (Map Area A), and the other related to a familiar area about three miles away from the school (Map Area B). The children were given minimum cartographic instructions. For example, they were told to draw the school, the school gate, the railings, pavement and junior playground on their maps relating to Map area A. The reason being, that at a later stage, the children were asked to draw a route on their maps, which started at the school gate, followed the pavement and finished in the junior playground. (Similar instructions were given for Map Area B). The children were also told to include in their map everything that they knew was there and could see if they walked the route that was mentioned in the researcher's instructions.

The findings and evaluation of the follow-up to the Pilot study

The aim of the follow-up to the pilot study was to determine if the five issues of concern existed when testing a larger number of children. Also to evaluate the results of the testing and to justify using the initial checklists while inserting the following modifications within the relevant checklists:

1 an emergent stage of development

2 organisational element to record discrete features

3 organisational element to record Ordnance Survey map features

And to explore further the extent to which children:

1 over-lap between developmental stages

2 are placed at different developmental stages between two map areas

The findings of the follow up to the pilot study relating to developmental stages are as follows:

The Emergent Stage of Development

Although none of the children in the pilot study were placed at the emergent stage, this stage was retained within the relevant checklist. As Table 2.3 showed, 25 (about one-third) children were placed at the emergent stage of development relating to Map Area A. Table 2.4 relating to Map Area B showed that ten (about one-seventh) children were placed the emergent stage of development. Placing children's drawn cognitive map representations into an emergent stage of development does not imply that these children do not possess any general mapping ability. It simply means that they have not yet reached the topological stage of development. They were unable to follow the researcher's instructions by depicting particular features on their drawn cognitive map representations and by drawing the start of a route at one of these features mentioned in the instructions. At the same time these children do possess general mapping ability that can be elicited through other general mapping variables and given a quantitative score.

Over-lapping between developmental stages

The following tables illustrate that the over-lapping of developmental stages was still being observed at the 'follow-up to the pilot study' stage. For example, Table 2.3 relating to Map area A showed that twenty one (about one-third) children and Table 2.4 relating to the other area (Map Area B) showed that 54 (about three-quarters) children were placed in the over-lapping stages of projective one and projective two developmental stages. It was expected that there would have been some over-lapping of stages, but not at such a high percentage.

Table 2.3. Number of 'follow-up to the pilot study' children's drawn cognitive map representations placed at different stages of development. (Map Area A)

	rec.	Y1	Y2	Y3	Y4	Y5	total No. chd	% of chd
Emergent	7	6	4	3	1	4	25	34.7
Topological	2	4	6	1	1	0	14	19.4
Projective 1	3	2	0	3	2	0	10	13.9
Projective 1 & 2	**0**	**0**	**2**	**4**	**8**	**7**	**21**	**29.2**
Projective 2	0	0	0	1	0	0	1	1.4
Euclidean	0	0	0	0	0	1	1	1.4
No.children	12	12	12	12	12	12	72	100

Table 2.4 Number of 'follow-up to the pilot study' children's drawn cognitive map representations placed at different stages of development. (Map Area B)

	rec.	Y1	Y2	Y3	Y4	Y5	Total No. chd	% of chd
Emergent	**6**	**1**	**0**	**2**	**0**	**1**	**10**	**13.9**
Topological	0	0	0	0	0	0	0	0
Projective 1	0	2	4	0	0	0	6	8.3
Projective 1 & 2	**6**	**9**	**8**	**10**	**12**	**9**	**54**	**75**
Projective 2	0	0	0	0	0	2	2	2.8
Euclidean	0	0	0	0	0	0	0	0
No.children	12	12	12	12	12	12	72	100

Different developmental stages between Map Area A and Map Area B

The third observation arising from the development of the instrument in the follow up to the pilot study showed that children show evidence of different cartographic concepts when constructing drawn cognitive map representations in different areas. As a consequence of this, some of their drawn cognitive map representations relating to Map area A were placed at a different stage of development than their drawn cognitive map relating to Map Area B. Table 2.5 showed that 42 (58%) children were at different stage development when constructing their drawn cognitive map representations of two different areas and thirteen (18%) children showed a wide difference of three stages

Table 2.5 'Follow-up children's' drawn cognitive map representations placed at different developmental stages between two map areas.

	rec.	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total No. chd**	**Number of children expressed as %**
same stage	6	2	1	6	8	7	30	41.7
one stage	3	1	3	4	2	2	15	**20.8**
two stages	2	5	5	1	1	0	14	**19.4**
three stages	1	4	3	1	1	3	13	**18.1**
							72	

Modifications to the checklist relating to Lynch's (1960) organisational elements

The fourth and fifth observations were concerned with the recording of discrete and Ordnance Survey map features depicted on children's drawn cognitive map representations. These features did not fit into Lynch's (1960) organisational elements of paths, nodes, landmarks, area/district or edges that were used as the initial framework to construct a cartographic features checklist in the development of this instrument. The checklist was modified during the pilot study, to include the two additional organisational elements of discrete and Ordnance Survey map features.

The Ordnance Survey map element

Table 2.6 showed that approximately 5% of the total number of features depicted by the follow-up to the pilot study children, on their drawn cognitive map representations relating to Map Area A, were Ordnance Survey map features. The number of Ordnance Survey map features relating to Map Area B amounted to approximately 6%.

The discrete feature element

Table 2.6 showed that approximately half (50.5%)of the total number of features depicted on their drawn cognitive map representations relating to Map Area A and nearly a third of the total number of features relating to Map Area B were discrete features. These results showed that in order to fully describe the children's responses both of these additional organisational elements should be retained within the checklist.

Table 2.6 Distribution of cartographic features into the seven organisational elements (Map areas A and B)

	Map Area A total No. features	**features shown as a %**		**Map area B** total No.features	**features shown as a %**
Paths	69	12.4		80	18
Nodes	1	0.2		4	0.9
Landmarks	140	25.3		152	34.2
Area	25	4.5		39	8.8
Edge	12	2.2		18	4
O.S. maps	**27**	**4.9**		**25**	**5.6**
Discrete	**280**	**50.5**		**127**	**28.5**
Totals	554	100		445	100

The aim of the follow-up to the pilot study was to determine if the five issues of concern existed when testing a larger number of children and the results of the testing showed that the five observations still existed. Therefore the initial checklists could be used in the main research, retaining the following modifications within the relevant checklists:

1 an emergent stage of development
2 organisational element to record discrete features
3 organisational element to record Ordnance Survey map features

The data arising from both pilot studies indicated that a substantial proportion of children were producing drawn cognitive map representations which:

1 over lapped at different stages of development
2 were assigned to different stages of development between the two different map areas.

The sample size, even in the follow up pilot was too small to allow these two observations to be fully explored. However, in the main study the issue would need to be fully addressed.

One of the follow-up to the pilot study children's drawn cognitive map representations relating to both Map area A and B illustrates each of the five issues of concern. (Figures 2.24 and 2.25)

Emergent stage of development

Barry's drawn cognitive map representation (Figure 2.24) relating to the Map Area A, illustrates that he was placed at the emergent stage of development. By completing the Yes/No checklist relating to stages of development it was found that Barry was unable to be placed at the topological stage because he did not follow the researcher's instructions by starting the route at the gate (see number 8 on Figure 2.24). Because he started his route at a house (see number 5 on Figure 2.24), Barry's drawn cognitive map representation was placed at the emergent stage of development. In order to develop an instrument that is both reliable and generalisable to the population, and to eliminate any subjectivity, the instructions for marking the checklists should be adhered to. For example, although Barry did include a route on his drawn cognitive map representation, he did not follow the instructions given by the researcher and start his route near the school gate.

Placing Barry's drawn cognitive map representation into an emergent stage development does not imply that he possesses no general mapping ability. It simply means that he has not yet reached the topological stage of development because no cartographic concepts were depicted on his drawn cognitive map representation. However, Barry was able to depict the cartographic features of a school, houses and a garden. He was also able to score in other variables relating to general mapping ability, that were not dependent solely upon the ability to draw, such as giving verbal responses. For example, when Barry was asked to describe the Mickey Mouse route,

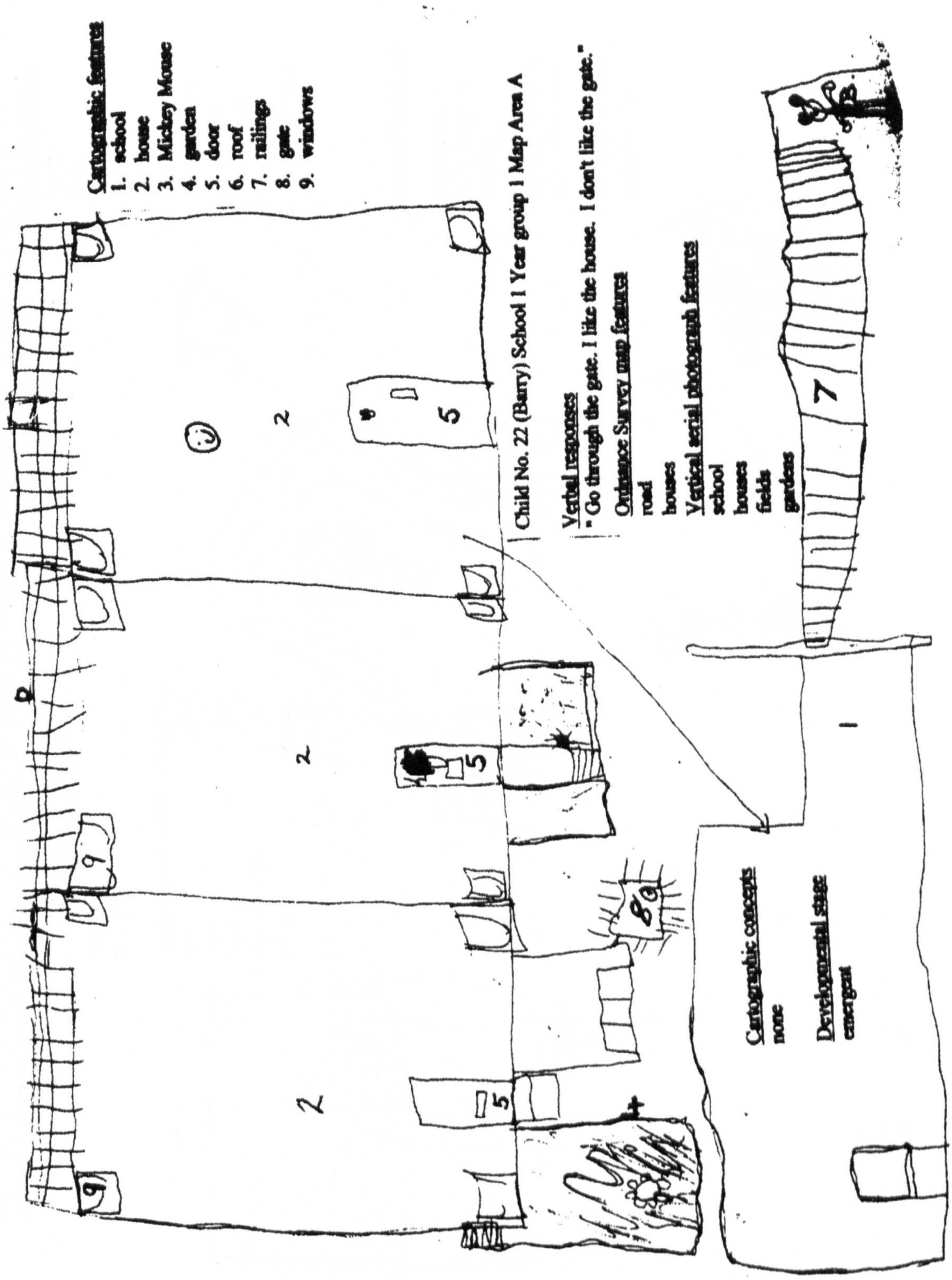


Figure 2.24 Cognitive map representation (Map area A) by Barry –Year group 1

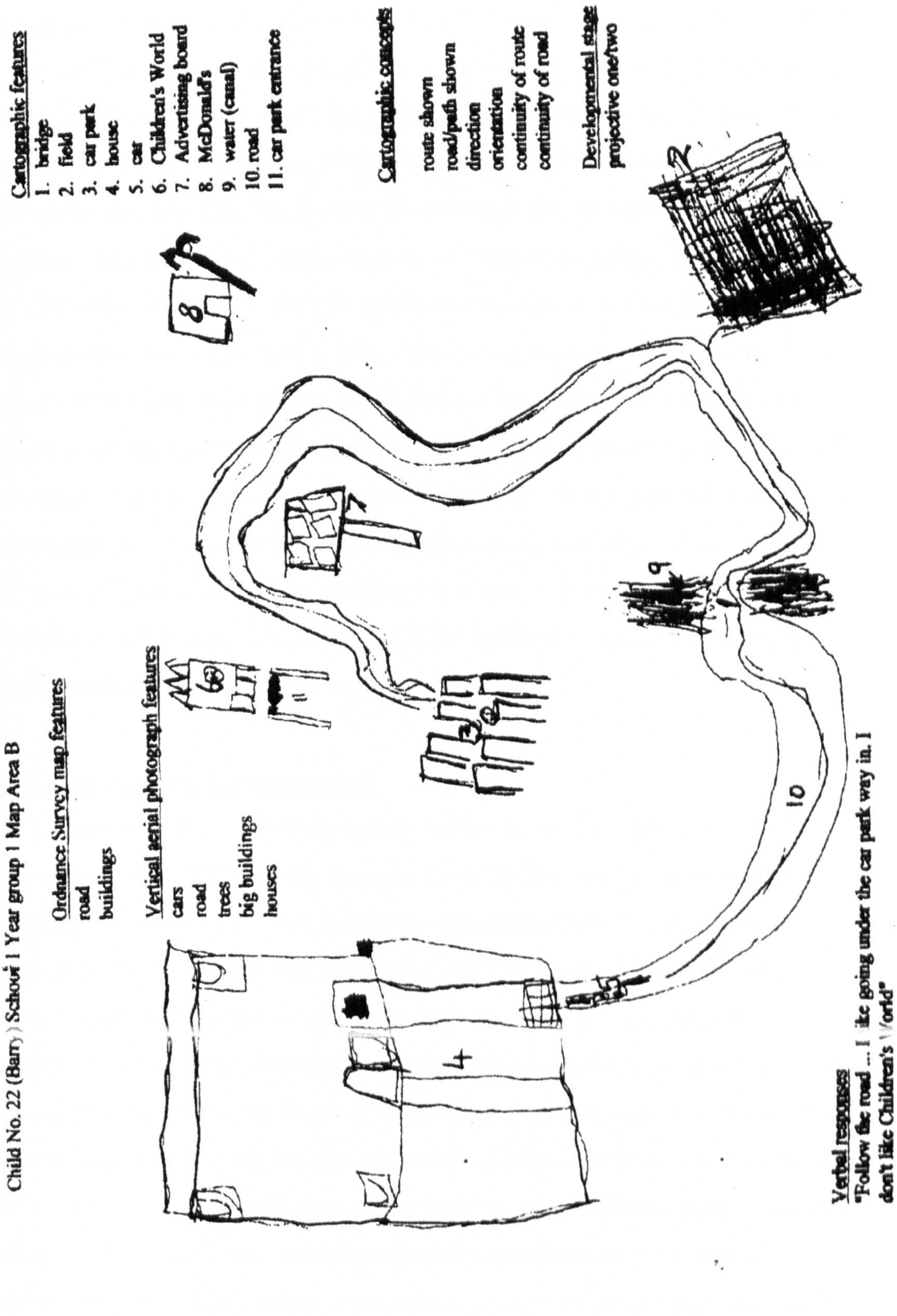


Figure 2.25 Cognitive map representation (Map area B) by Barry –Year group 1

he repeated the researcher's instructions, not the route he had drawn on his cognitive map representations. His verbal response was, "Go through the gate". The words "go" and "through" are relevant directional terms. He was also able to identify roads and houses when shown a section of a large scale Ordnance Survey map of Map Area A, and identified the school, houses, fields and gardens on a vertical aerial photograph of the same area. The affective domain of environmental perception was another variable contained within the umbrella term of 'general mapping ability' (Siegal 1982, Golledge 1999) and tested through verbal responses. The house drawn by Barry must have been important to him, because when asked if there was anything on his map that he liked, his response was "I like the house", but he couldn't give a reason why he liked the house. When considering dislikes, his response was "I don't like the gate". Again, he couldn't give a reason. Barry's verbal responses have shown that even though his drawn cognitive map representation of Map Area A was placed at the emergent stage because no cartographic concepts were identified, Barry was able to make verbal responses relating to other variables of 'general mapping ability', that were not dependent solely upon the ability to draw.

Over-lapping stages of development

Barry's drawn cognitive map representations relating to Map Area B (Figure 2.25), shows an example of the over-lap between the projective one and projective two developmental stages. His drawn cognitive map representation depicts the route starting by his house and car (see numbers 4 and 5 on Figure 2.25). The route followed a road (see number 10 on Figure 2.25) until it reached a car park (see number 3 on Figure 2.25). Although not connected by either the route or road, Barry did include Children's World and McDonald's (see numbers 6 and 8 on Figure 2.25). His drawn cognitive map representation showed evidence of direction and orientation at the projective one stage of development, because Barry's drawn route started at his house and finished in the car park close to Children's World and McDonald's (number 3 on Figure 2.25). However his drawn cognitive map representation did not show evidence of direction and orientation at the projective two stage of development because, excluding the discrete features of the car, advertising board and car-park entrance, Barry only depicted eight cartographic features. The criteria outlined on the checklist was:

> Improvement in direction (and orientation) Does the route follow the road/path, start at the child's home and finish at either Children's World or McDonald's? (Breaks in continuity NOT accepted and at least nine cartographic features identified)

The difference between the projective one and the projective two stages relating to the concepts of direction and orientation was that at the projective one stage breaks in continuity were accepted, but at the projective two stage breaks in continuity were not accepted and at least nine cartographic features should have been depicted on the drawn cognitive map representation. Therefore, the concepts of direction and orientation at the projective two stage had not been achieved because of insufficient detail depicted on drawn cognitive map representation. These differences took into consideration an element of progression between the same concept at different stages of development.

The following cartographic concepts were depicted on Barry's drawn cognitive map representation relating to Map Area B: -

1. route
2. road/path
3. direction
4. orientation
5. continuity of route
6. continuity of road/path
7. sufficient detail

The results showed that Barry's drawn cognitive map representation was placed at the over-lapping stage between the projective one and projective two developmental stages.

Different stages of development between two different map areas

An example of this observation was shown on Barry's drawn cognitive map representations. His drawn cognitive map representation relating to Map Area A was placed at the emergent stage (Figure 2.24), yet his drawn cognitive map representation relating to Map Area B was placed at the over-lapping stage of projective one and projective two stage (Figure 2.25).

Discrete features depicted on drawn cognitive map representations

Barry's drawn cognitive map representation (Figure 2.24) relating to Map area A depicted the discrete features of Mickey Mouse, railings, gate, doors, roofs and windows. Figure 2.25 shows Barry's drawn cognitive map representation relating to Map Area B depicting a car, an advertising board and the car-park entrance.

Ordnance Survey map features depicted on drawn cognitive map representations

Barry did not depict any cartographic features that could be included within the additional organisational element of Ordnance Survey map features on his drawn cognitive map representation (Figure 2.24) relating to Map Area A. However, on his drawn cognitive map representation relating to Map Area B Barry identified a car park (see number 3 on Figure 2.25). Although a car park can be identified on a large scale Ordnance Survey map, this feature cannot be recorded within any of Lynch's organisational elements, and therefore was recorded within the additional organisational element of Ordnance Survey maps.

CHAPTER 3

THE METHODOLOGY: THE MAIN STUDY

Statement of problem

As previously mentioned in the pilot study the literature review has shown that most of the general mapping variables have been separately tested, measured and the ability and development of children relating to both gender and the different year groups have been identified (Piaget 1955, Catling 1978, Hart 1979, Matthews 1984c, Blades and Medlicott 1992 and Taylor 1998). However, to date there has not been an attempt to find a general measure of children's overall mapping ability. The data arising from both pilot studies showed that the developed instrument could be used (with modifications) as a framework for using children's cognitive map representations as a measure of their 'overall general mapping ability'. However, the data also indicated that a substantial proportion of children were producing drawn cognitive map representations which were assigned to overlapping stages of development when considering either Map Area A or B and different stages of development when considering Map Area A and Map area B. However, the sample size, even in the follow up pilot was too small to allow these issues to be fully explored and in the main study it was clear that the issue would need to be fully addressed.

Before deciding on the population and the sample size, it was considered necessary to address similar research, and Table 3.1 shows details of some of the research studies addressed in the literature review. However, the studies vary widely in the number of children being tested, and gave no clear indication of the number of children required for research of this nature.

Table 3.1 Researchers' names, dates and number of children tested

	Number and age of children being tested
Blades & Spencer 1986	60 children (3 to 6 years)
Blades & Spencer 1987	120 children (3.8 to 6.3 years)
Blades et al 1998	144 children (4 years)
Joshi et al 1999	93 children (7 to 11 years)
Matthews 1986c	59 children (6 to 11 years)
Matthews 1984b	155-172-174 children (6-11 years)
Matthews 1984a	172 children (6 to 11 years)
Matthews 1985b	253 children (6 to 7 years)
Stea & Blaut 1968	140 children (35x4) 6 year olds
Wickstead 1991	76 children (4 to 11 years)

Gay (1992) argued that:

> There are some guidelines that can be applied in order to determine what size sample is "big enough". In general, the minimum number of subjects believed to be acceptable for a study depends upon the type of research involved. For descriptive research, a sample of 10% of the population is considered minimum. For smaller populations, 20% may be required. For correlation studies at least thirty subjects are needed to establish the existence or non-existence of a relationship. For causal-comparative studies and many experimental studies, a minimum of 30 subjects per group is generally recommended. Using samples larger than the minimum is especially important in certain situations. For example, differences might not "show up" if the samples are too small
>
> (Gay, 1992, p.137)

Taking into consideration the argument presented by Gay and also being aware that the kind of analysis anticipated is also relevant to the sample size selected, the criteria was to use a large, yet manageable sample based on an average sized primary school and by taking into consideration the objectives contained within the following research questions:

"Can a method be developed to measure children's overall general mapping ability?"

"Can it be used across the primary age range with a wide variety of pupils at different stages of development?"

"Should an emergent stage be included to accommodate children who could not be placed into a stage of development?"

"Are there gender differences in mapping ability?"

To ensure that the population and sample were both representative and sufficiently large for the research results based on it to be generalizable to the population, the present research involves a stratified sample of two hundred and fifty two children (between 5 and 11 years) from a population of approximately eight hundred primary school children from three different schools. The stratified sample (equivalent to one-third of the population) involved equal numbers of girls and boys from each of the seven primary school year groups. This was confirmed as an appropriate realistic number by the researcher's supervisors at an annual review.

The population

As the research was concerned with general mapping ability, it was considered important that the children taking part in the tests were surrounded by a good range of geographical features, for example, roads, motorways, waterways, railways, farmland, housing and industry. The choice of the population was therefore geographically determined. It comprised of three schools (matched for social class), along an east/west linear transect, from the coast to the boundary, within a Metropolitan Borough in the North West of England. The children from the three different schools were surrounded by different geographical features that could be identified on both large scale Ordnance Survey maps and vertical aerial photographs. Using children from the different environments instead of using all children from one school provided a more generalizable picture of what children can cartographically identify.

At the request of the schools involved, the three schools were used as one sample, as the schools in question did not want the research results to be compared. This was acceptable, as it did not conflict with the purpose of the research of developing an instrument as a means of measuring cognitive map representations, in order to produce reliable and generalisable judgements about the present state of primary school children's overall general mapping ability. The three schools involved were: -

School 1 is situated within a semi-rural village and is the only school in the village. This school was used for the pilot studies and Figure 2.22 is a vertical aerial photograph showing the cartographic features surrounding the school, such as housing, a playing field, farmland, a light industrial area, B class roads, a motorway and a canal, a bridge and a railway.

School 2 is situated at an equal distance between the other two schools. Prior to the 1950's, the land in this area was predominantly farmland. During the 1950's, it was developed, not as a new town, but of a similar design. Figure 3.1 is a vertical aerial photograph showing the cartographic features surrounding the school. It is mainly urban housing, schools and open space. The open space consists of school grounds, parkland and a golf course. Both A and B class roads can be identified on the vertical aerial photograph, as well as bridges and roundabouts.

School 3 is situated on the coastal edge of a river, north of a dock system and close to a marina. Figure 3.2 is a vertical aerial photograph showing the cartographic features surrounding the school. It is mainly urban housing and open space. The open space consists of parks, a Marina, sand dunes, the beach and a river, Both main roads and side roads can be identified on the vertical aerial photograph, as well as railway lines, a car park and bridges.

The three schools contained within the population each followed the National Curriculum Guidelines and used the Metropolitan Borough's National Curriculum Guidance Policy and resources for geography. This common and equal exposure provided an ideal criterion for selecting schools for this research within this particular Metropolitan Borough.

Figure 3.1 Vertical aerial photograph showing cartographic features surrounding School 2

Figure 3.2 Vertical aerial photograph showing cartographic features surrounding School 3

The sample

A stratified sampling technique was appropriate for this research because of the implications highlighted in the research question. The research question being "Can a method using children's cognitive map representations (both drawn and verbal be developed as a means of measuring children's overall general mapping ability? If so, can it be used across the primary age range with a wide variety of pupils at different stages of development?" As the purpose of stratified sampling is to guarantee desired representation of relevant subgroups this technique allowed the selection of equal sized samples from each of the year groups and gender subgroups. It involved two hundred and fifty two primary school children (eighteen boys and eighteen girls from each of the seven primary year groups divided equally between the three schools).

The stratified sampling technique used was to classify all members of the population by using the class registers (excluding children absent on the day of the test). The random sampling technique of writing children's names on pieces of paper, put in 'girls' and 'boys' containers was used. Six names from the two containers for each of the year groups in each of the three schools were selected in order to have equal numbers of girls and boys from each of the seven primary school year groups. The selection task was carried out in front of all children from the population on completion of the first stage of the testing. The first stage of testing involved all children in each of the year groups (class by class in each of the three schools) constructing two drawn cognitive map representations of two different familiar areas. It was then explained to the children, before the random sampling took place, that some of them would be chosen to "do some more work on their maps".

The instrument

The first element to be addressed in the development of the instrument was the construction of checklists to record children's responses relating to each of the above variables. The contents of the checklists took into account the definitions of general mapping terms by (Catling, 1978&1981; Bale, 1987; Mills et al, 1988; Harrison and Harrison, 1989; Boardman, 1990; Weigand, 1993; Marsden and Hughes, 1994). The second element was the development of procedures to be followed in order to elicit children's responses. The third element to be addressed was the testing, interpreting and scoring of the instrument.

The development of the checklists

The development of the checklists was addressed in depth in the pilot study. No modifications were made to the following checklists, which were used in the main study:

1 Stages of development relating to the drawn cognitive map representations (Figure 2.1 in the pilot study)
2 Cartographic concepts (Figure 2.2 in the pilot study)
3 Verbal directional responses (Figure 2.3 in the pilot study)

Modifications were made to the checklist used in the pilot study for recording responses relating to the following variables:
cartographic features
environmental perception
Identification of features depicted on large scale Ordnance Survey maps
Identification of features depicted on vertical aerial photographs

As mentioned earlier, this checklist was modified to include discrete and Ordnance Survey map features. These additional organisational elements were included because some features such as a sandy slope, the bus stop, names of roads and railway embankments were depicted on children's drawn cognitive map representations but they could not be recorded within Lynch's (1960) organisational elements of paths, nodes, landmarks, area/district or edges. Figure 3.3 shows the modified checklist including the two additional organisational elements of discrete and Ordnance Survey map features to be used in the main study.

Figure 3.3 CHECKLIST FOR RECORDING CHILDREN'S RESPONSES INTO LYNCH'S (ADAPTED) MAJOR ORGANISATIONAL ELEMENTS

Child number____Sex____ Year group____ School Area ________

Concepts (see below)	1	2	3	4	5	6	7
PATHS 1. bridges /tunnels 2. roads/paths/pavements/trails. 3. dual carriageways 4. motorways							
NODES 5. major road sections 6. churches 7. fire stations 8. railway stations 9. bus stations 10. police stations 11. hospitals							
LANDMARKS 12. Own School/ own house 12a Own School grounds 13. Deyes Lane School/Baths 14. Children's World/ McDonald's							
AREA/DISTRICT 15. houses 16. gardens 17. garages 18. surgeries 19. shops 20. fast food 21. clinics 22. libraries 23. other schools 24. club buildings other buildings							
EDGES 25. rivers/streams/ canals 27. farmland/parkland/fields 28. railway lines other							
OS MAPS (not included above) 29. pond/lake 30. embankments 31. road names 32. house numbers 33 key/title 34 car park 35. compass							
CHILDREN'S DISCRETE FEATURES							
TOTAL							

Variables: - 1. features on map. 2. likes. 3.reasons. 4.dislikes. 5. reasons.

6. features on O.S. map. 7. features on aerial photograph.

THE PROCEDURE

INSTRUCTIONS TO THE CHILDREN

Only an outline of the procedure and instructions to the children follows, as this was addressed in the pilot study. Two different familiar areas were tested, because children think differently about different areas (Piaget 1971: Matthews 1985a). Most research suggested that the areas around the children's homes and from their homes to school were familiar areas. However, using the home to school area would give some children an unfair advantage, because some children may live near to the school, while others may live up to three miles away. On the one hand, it might be expected that children living further away from the school had the opportunity to identify more cartographic concepts and features on their drawn cognitive map representations. On the other hand, the children living further away from the school and travelling by car, and only following the route in a passive manner could be at a disadvantage, because the children closer to the school, may be walking or cycling and following the route in an active manner. Therefore, in order to ensure the instrument was generalisable to the population, the school perimeter route was used as one of the familiar areas, the other familiar area being a route covering a distance of approximately three miles.

The children were asked to: -

i draw maps of two familiar areas; (a) their school perimeter (referred to as Map Area A) and (b) another specified familiar area approximately two to three miles from their school (referred to as Map Area B).

ii draw a route on both maps and verbally describe both routes using directional vocabulary.

iii draw ('happy/unhappy' faces) against some features on both maps and then verbally describe their likes and dislikes (and reasons) for the inclusion of these features

iv verbally identify features on Ordnance Survey maps (1:12500), and coloured vertical aerial photographs (1:1000) of Map Areas A and B. The maps and photographs were firstly adjusted to ensure that they were approximately the same scale and identified the same area.

THE FIRST STAGE

Informal discussion

An informal discussion was undertaken to enable the researcher and children to become familiar with each other prior to the testing. For example, the researcher used the following words: -

" I want you to draw a map for me"

"But do you know what a map is and what it is used for?"

Although this was a familiarisation session, it was important, as the two questions asked of the children were vital concepts in general mapping. The children were shown a side-view photograph a vertical aerial photograph, and a section of a 1:1250 Ordnance Survey map of their particular school. Each of the illustrations was shown separately to the children who were asked the same question, "Is this a map?" If they gave an incorrect response, the children were told what was depicted on that particular piece of paper. The instructions were repeated until the correct response of identifying the map was given (A full account of the instructions is outlined in the pilot study). Before the children constructed their drawn cognitive map representations they were told stories containing the cartographic features.

THE SECOND STAGE

The story

The story was altered to suit each of the three schools for both Map Areas A and B, but basically the children's intended cognitive map representations should include a route partially (or completely) around the school perimeter for Map Area A, and to include features such as the school building or buildings, school grounds, perimeter road, houses and churches.

School 1 (Map Area A)

"Mickey Mouse was standing by the main school gate. He wants to go to the Headteacher's office, but he doesn't know the way. Can you help him? The problem is, he is not allowed to go through the main school gate into the school grounds. He has to start outside the main school gates and walk along the pavement next to the school railings until he gets to the old gates. Mickey Mouse will need to climb over the old gates and 'line up' with the children when the bell goes. One of the teachers will take Mickey Mouse to the Head-teacher". The children were asked to draw a map to help Mickey Mouse to find the way. Figure 2.15 (pilot study) shows a section of an Ordnance Survey map outlining the route described in the story.

School 1 (Map Area B)

The story for the reception, Year group one and Year group two was that they had been invited to a party at McDonald's (situated on a retail park approximately three miles from their homes. But first they had to go to Children's World (situated on the same retail park) to buy a present. Could they draw a map to show the way? Figure 3.4 shows a section of an Ordnance Survey map showing the route outlined in the story.

School 1 (Map Area B)

The story for Year groups three, four, five and six was that the driver of the coach taking them to the swimming pool did not know the way and would they draw a map for him. The route would start at the main school gate and finish at the swimming pool. Figure 3.5 shows a section of an Ordnance Survey map showing the route outlined in the story.

School 2 (Map Area A)

The story for School 2 was that Mickey Mouse went into the school looking for the headteacher. The school secretary told him that the headteacher was in church with the schoolchildren. Mickey Mouse went to the church but was told he couldn't go into the church because the children were rehearsing. He was told to start at the church door, walk down the path, through the gate, then walk along the pavement by the railings until he got to the school gate. Go through the school gate and walk down the path until he got into the playground and wait there for the headteacher and the children to arrive back from church. The children were asked to draw a map for Mickey Mouse to show him how to get from the church door and into the school playground. Figure 3.6 shows a section of an Ordnance Survey map showing the route outlined in the story.

School 2 (Map Area B)
The children were in assembly and they were told that they were to have a special treat. A coach would be arriving at the school gate to take them to the shopping precinct, but the driver didn't know the way. Would they draw a map to show the driver the way, by starting at the school gate and drawing everything that they would see on the way, until they arrived at the shopping precinct? Their maps would help the driver to find his way. Figure 3.7 shows a section of an Ordnance Survey map showing the route outlined in the story.

School 3 (Map Area A)
The story for School 3 was identical to the story told for School 2. However, because the school building for the reception, Year groups one and two is on a separate site from the other year groups, the Ordnance Survey map outlines the different routes mentioned in the story. (Figure 3.8)

School 3 (Map Area B)
The children were in assembly and were told that a coach would be arriving at the school gate to take them to the swimming pool. But there were two problems. Firstly, the headteacher wanted them to stop at Woolworths and the library before they the children could go to the swimming pool. Secondly, the driver of the coach did not know the way and would they draw a map for him. The route would start at the main school gate; go to Woolworth's and then to the library before going to the swimming

Figure 3.4 Map showing route from School 1 to Retail Park

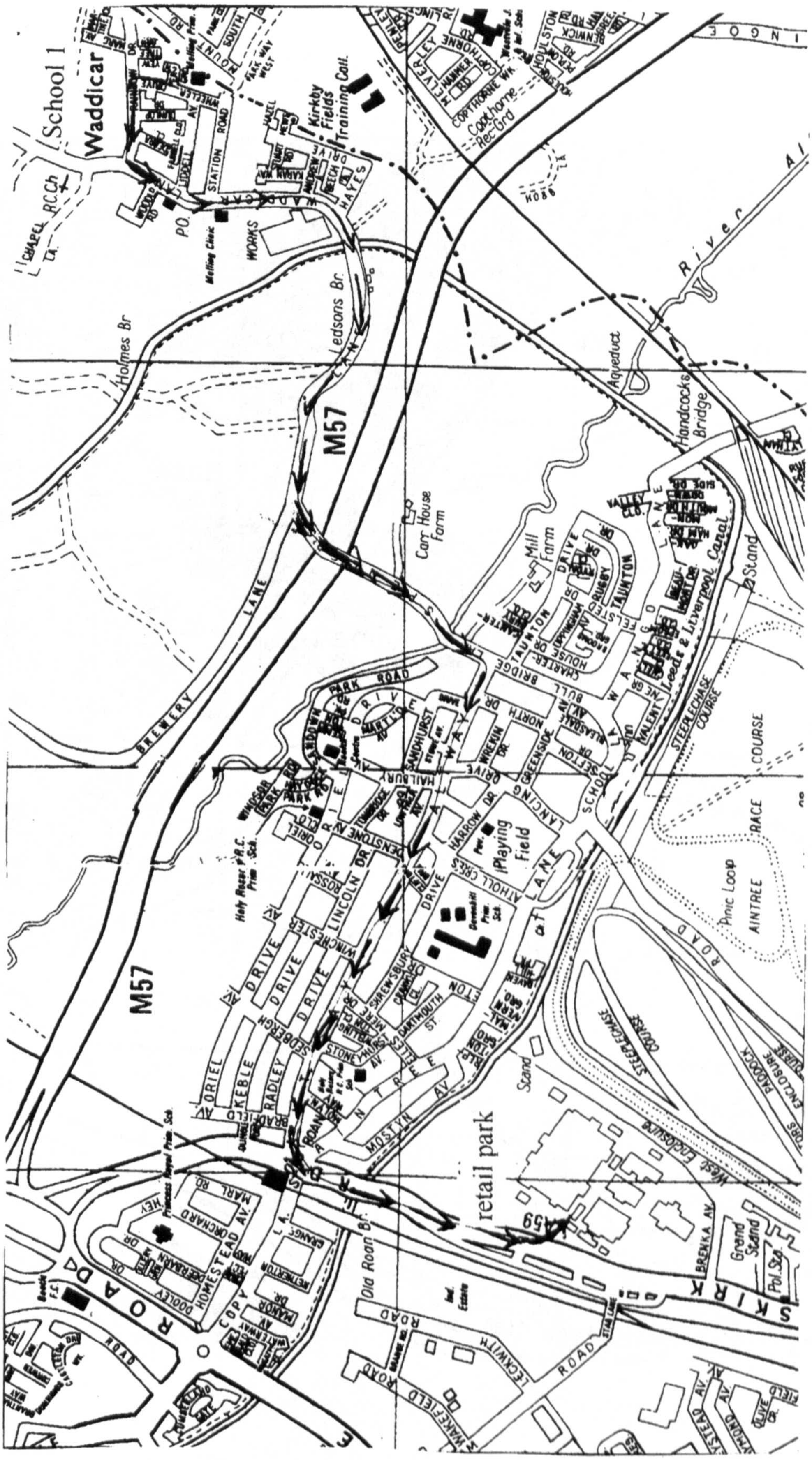


Figure 3.5 Map showing route from School 1 to the swimming pool

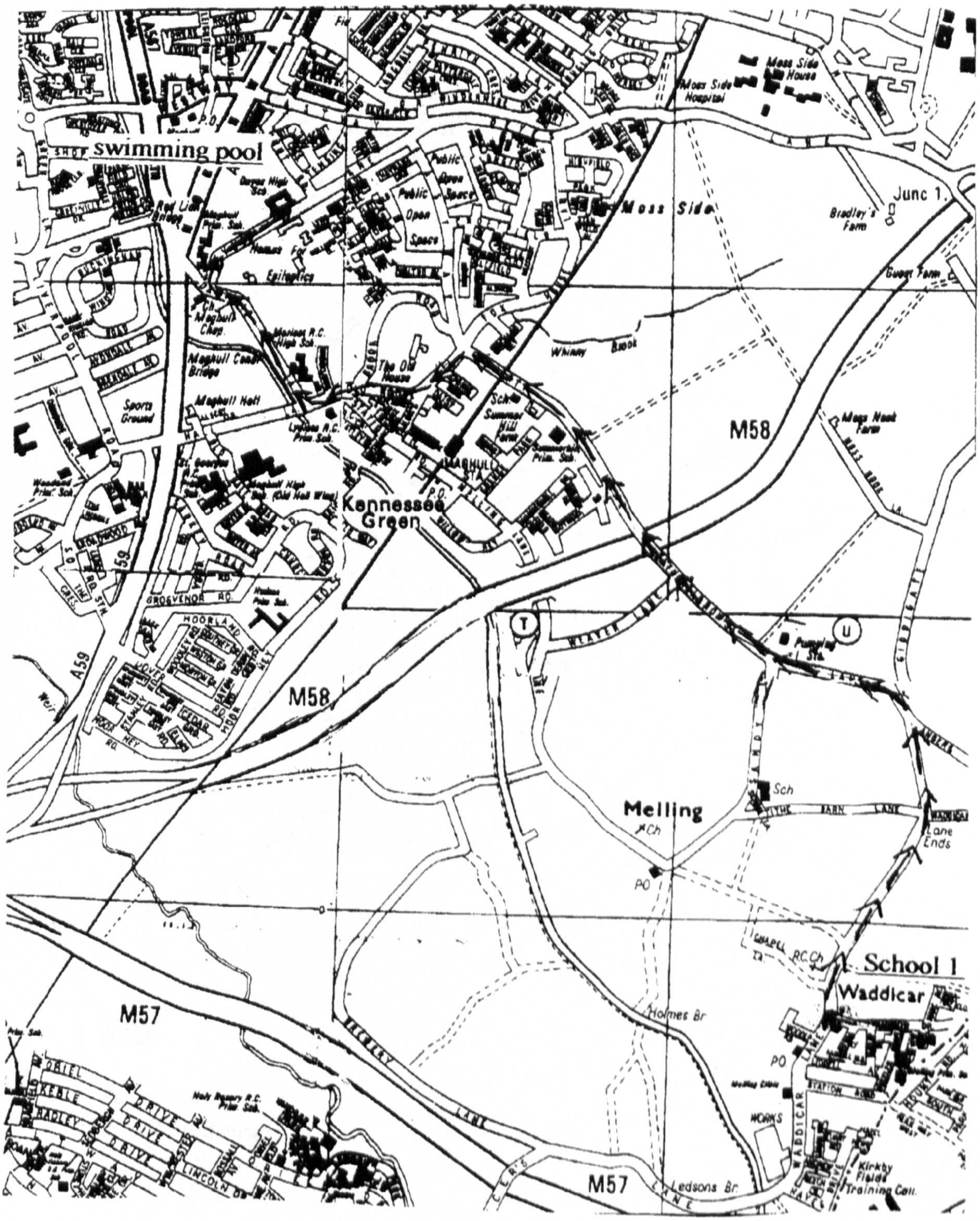
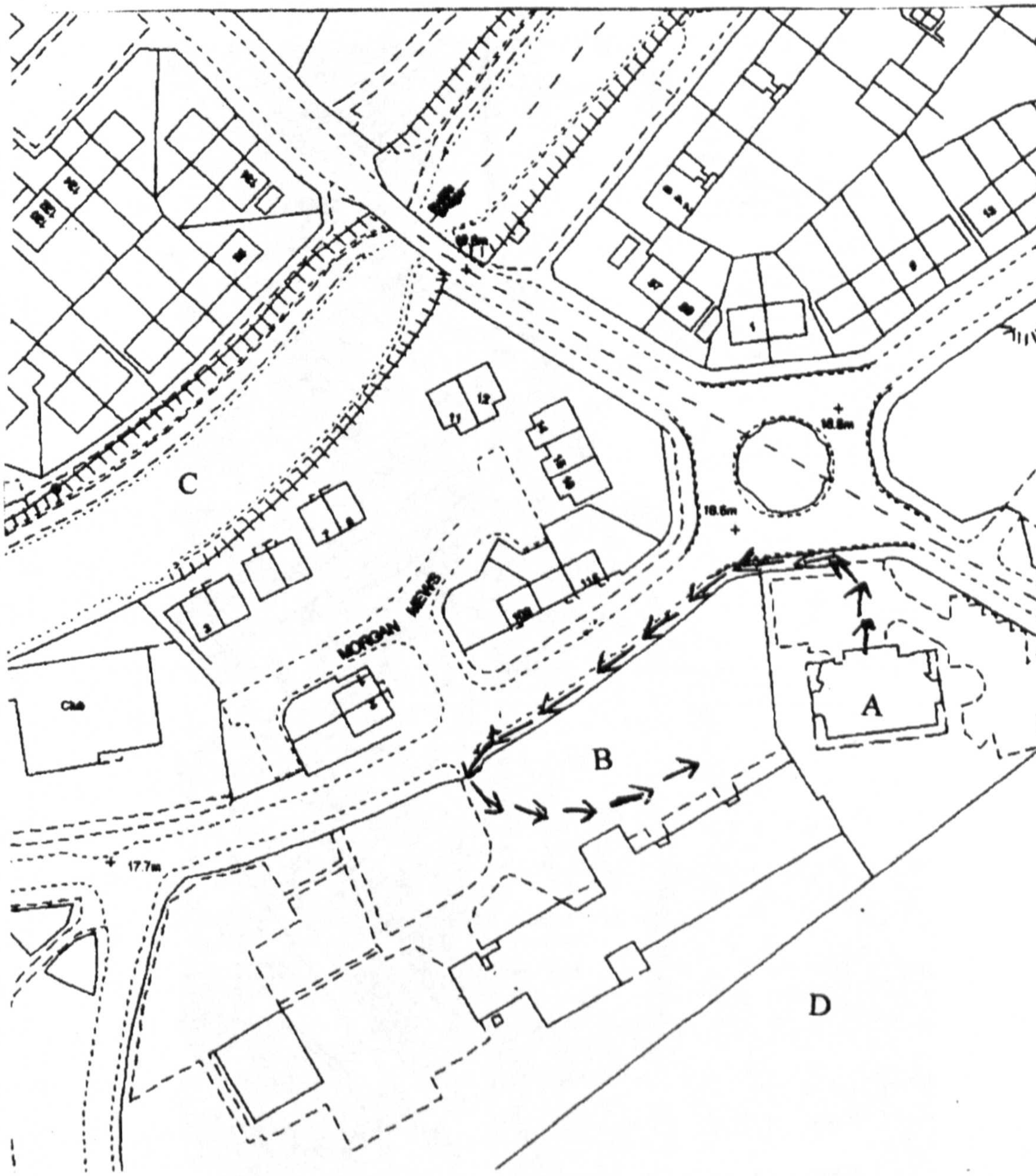


Figure 3.6 Map showing route from School 2 to the church



KEY

A Church
B Playground
C Canal
D Golf course

Figure 3.7 Map showing route from School 2 to the shopping precinct

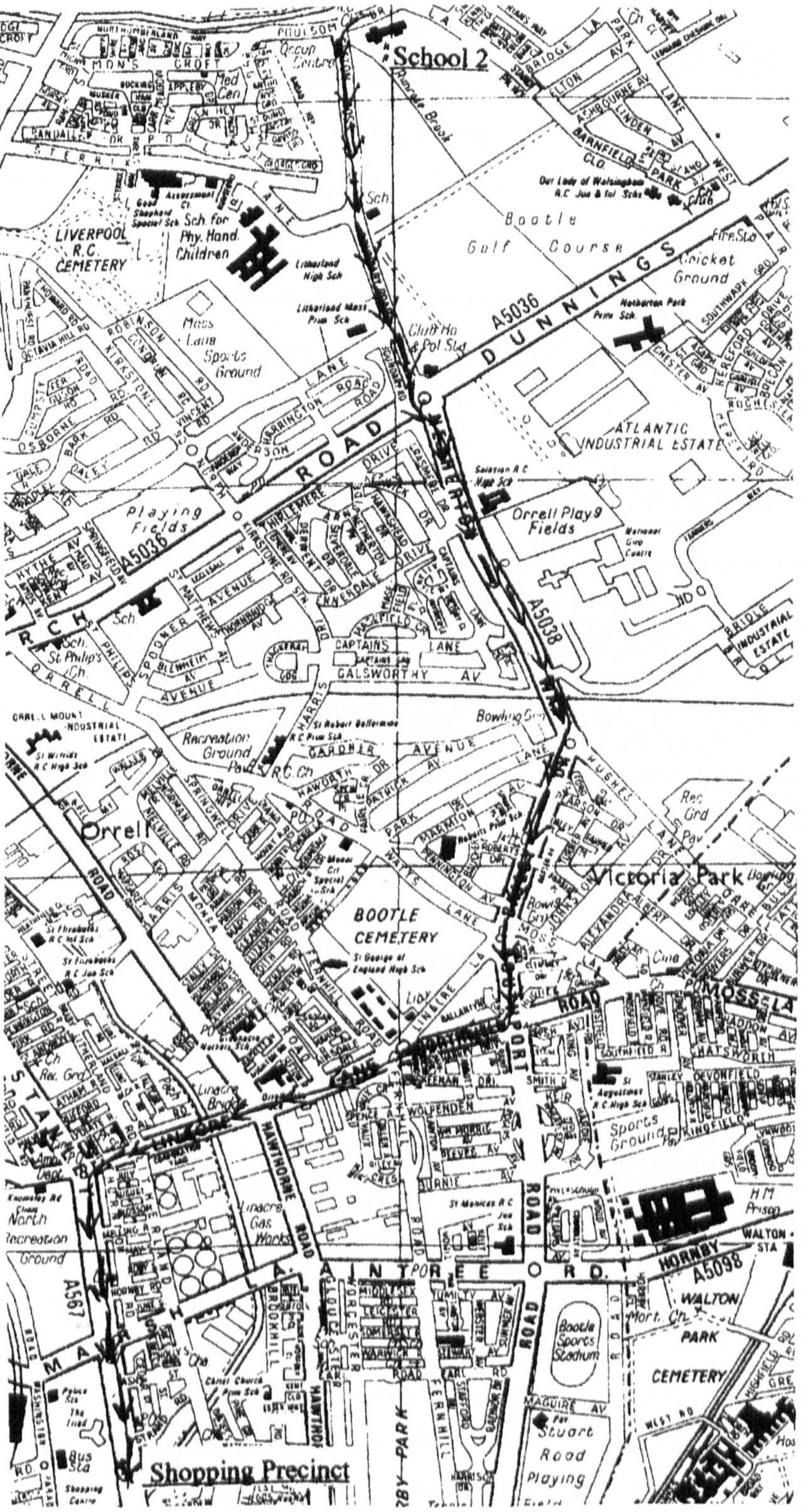
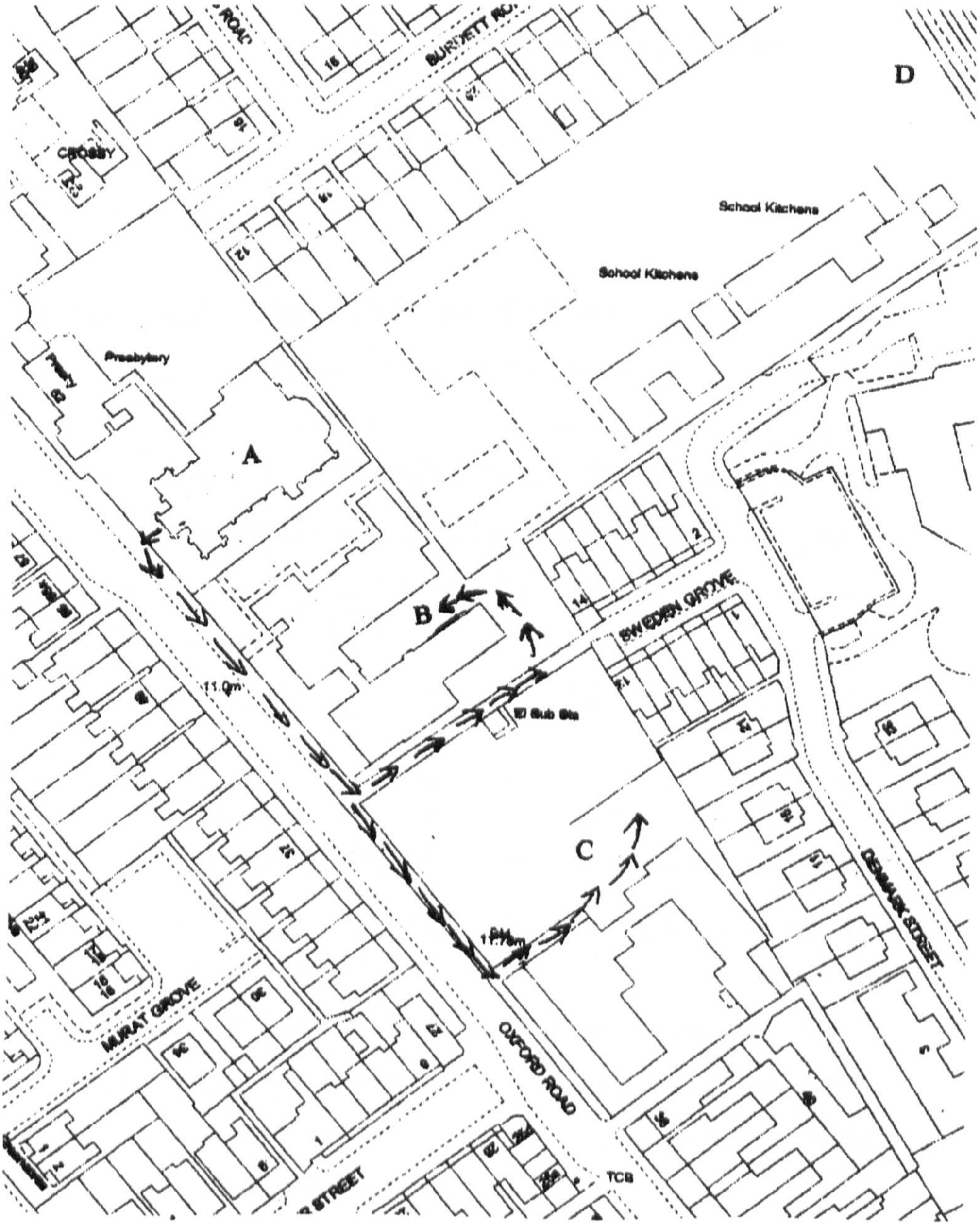


Figure 3.8 Map showing route from church to Infant and Junior playgrounds (School 3)



KEY

A Church
B Junior playground
C Infant playground
D Railway track

pool. The reason for the slight change in the story was that the swimming pool used by School 3 and was familiar to the majority of children, but only one mile away from the school. By extending the route between the school and the swimming pool to include diversions to two familiar buildings it was possible to lengthen the route to approximately two miles in distance. Figure 3.9 shows a section of an Ordnance Survey map showing the route outlined in the story.

THE THIRD STAGE

THE DRAWN COGNITIVE MAP REPRESENTATION

The drawn cognitive map representations were constructed on A3 sized paper, using a black inked pen. There were two reasons for using black inked pens, the first being that they give a distinct print, and enabled the production of clear and eligible photocopying for administrative purposes. The other reason being that using pens instead of pencils ensured that the correct cartographic tools were used consistent with an element of good cartography.

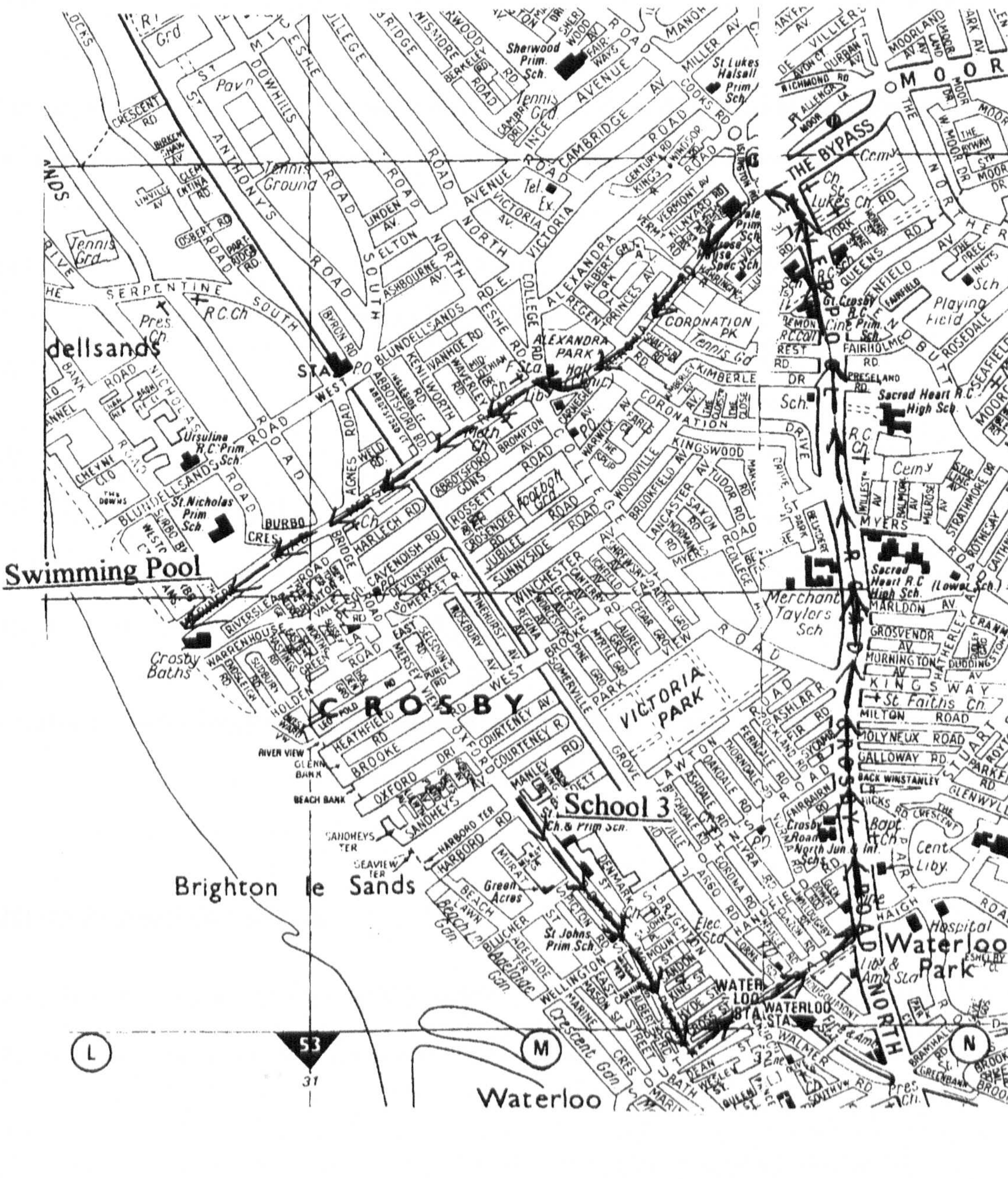
THE FOURTH STAGE

On completion of the drawn cognitive map representations by all children in each of the year groups (class by class in each of the three schools), it was explained that some of them would be chosen to do some more work on their maps. The random stratified sampling technique of writing children's names on pieces of paper; put in 'girls' and 'boys' containers was used. Six names from the two containers were selected in order to have equal numbers of girls and boys from each of the seven primary school year groups. The selection task was carried out in front of all those classes of children from which the sample was drawn.

THE FIFTH STAGE

The children chosen from the random sampling were removed from the classrooms and group or "one to one" work was carried out. The 'one to one discussions' were important in order to determine that the children understood what was being asked of

Figure 3.9 Map showing route from School 3 to swimming pool



them and that the researcher understood what was in the children's minds. (Donaldson 1978). This has already been outlined in the pilot study. The first task was concerned with "one to one discussions". " Tell me about everything that you have drawn on your map with the black pen" (all features were verbally identified by each child) and later displayed on their drawn cognitive map representations by the researcher. Depending on the age and development of each child, they were asked, either in a group or individually, to draw a route on both maps and verbally describe the routes. They were then asked to draw ('happy/unhappy' faces) against some features on both maps and verbally describe their likes and dislikes (and reasons) for the inclusion of these features. Finally they were shown Ordnance Survey maps (1:12500), and coloured vertical aerial photographs (1:1000) relating to Map Areas A and B and asked to identify features depicted on the maps and photographs. They were told to touch the features and say what they were in order to ensure correct identification.

THE SIXTH STAGE

The sixth stage comprised of two parts; the first part involved the completion of the children's cognitive map representations, when both the drawn and verbal responses were recorded visually on the children's drawn cognitive map representations by the researcher. The second part involved using the information depicted on the drawn cognitive map representations to complete the checklists. The data from each of the checklists was stored and subjected to statistical analysis using the SPSS for Windows computer package.

Inter-rater reliability check

Instructions for testing, interpreting, scoring and recording the instrument were completed, and implemented in the pilot study. The instrument was evaluated by a second-scorer for reliability at an inter-rating of 95%. However, the sample produced a much wider range of responses from the children taking part in the testing, which were not taken into consideration during the pilot study. Therefore some minor interpretation and scoring adjustments relating to the checklists were necessary, and hence the need for another inter-rater reliability check. The inter-rater reliability check involved approximately 7% (eighteen children) from the two hundred and fifty-two children taking part in the stratified sample. They were randomly selected from each of the seven primary school year groups in the three schools taking part in the main study (Table 3.2).

INSTRUCTIONS FOR CHECKING

The instructions to the second scorer were identical to the procedures outlined in the pilots study involving both the instructions given to the children and instructions for the interpretation and scoring of the checklists. Un-marked checklists for marking 'blind' and copies of the eighteen children's drawn cognitive map representations were also provided to the second scorer. All features depicted by the children on their drawn cognitive map representations were verbally identified by them, as it was important for the researcher to understand the children's interpretation of their maps (Donaldson 1978). No matter how explicit a feature looked on the drawn cognitive map representations, the researcher touched each feature and the child was asked, "What is this"? The aim was to objectively identify all features depicted by the children (including spaces if these appear relevant) and for administrative purposes it was convenient to number every feature and record the children's verbal responses on their drawn cognitive map representations. In addition, verbal responses relating to direction, environmental perception, features on large-scale Ordnance Survey maps and vertical aerial photographs were also depicted on the drawn cognitive map representations by the researcher.

THE CHECKLISTS

Because the children were from three different schools and different large-scale familiar environments were being tested, seven separate large-scale Ordnance Survey maps were provided to the second scorer. For example, if a child from School 2 constructed a drawn cognitive map representation relating to Map area B, the route involved in the researcher's instructions is shown on Figure 3.8. Table 3.2 outlines the additional information required by the second scorer in order to mark the checklist relating to the stages of development variable.

Stages of development checklist

To make the interpretation and scoring as objective as possible, the checklist for interpreting the drawn cognitive map representation involved changing Catling's (1978) illustrated table (Figure 1.3) into questions, which produced 'Yes' or 'No' answers (Figure 2.1). For purposes of checking, the following were required:

unmarked checklist (Figure 2.1)

large-scale Ordnance Survey map depending on child identity number (Table 3.2)

drawn cognitive map representations (drawn and numbered 'features' are sufficient to complete this checklist)

Table 3.2 Additional information required by second scorer for reliability check.

Child identity number	Map required for marking	Route shown on map, identical to instructions
3	Figure 3.4	School 1 to Retail Park
14	Figure 2.15	School 1 -main gate to junior playground
32	Figure 3.4	School 1 to Retail Park
41	Figure 2.15	School 1 -main gate to junior playground
50	Figure 3.5	School 1 to swimming pool
81	Figure 2.15	School 1 -main gate to junior playground
85	Figure 3.6	School 2 – church to playground
93	Figure 3.7	School 2 to shopping precinct
100	Figure 3.6	School 2 – church to playground
122	Figure 3.7	School 2 to shopping precinct
149	Figure 3.6	School 2 – church to playground
155	Figure 3.7	School 2 to shopping precinct
178	Figure 3.8	School 3 - church to Infant playground
185	Figure 3.9	School 3 to swimming pool
203	Figure 3.8	School 3 - church to Infant playground
205	Figure 3.9	School 3 to swimming pool
241	Figure 3.8	School 3 – church to junior playground
251	Figure 3.9	School 3 to swimming pool

Cartographic concepts checklist

For purposes of checking, a marked checklist by second scorer relating to stage of development (Figure 2.1) and an unmarked checklist relating to cartographic concepts (Figure 2.2) were required. The completed 'stages of development' checklist will have automatically identified cartographic concepts and this information can be explicitly transferred to complete the 'cartographic concepts checklist'.

Verbal directional responses checklist

For purposes of checking, the following were required:

unmarked checklist (Figure 2.3)

drawn cognitive map representations

The children's verbal responses relating to the route drawn on their maps, has been recorded by the researcher on the drawn cognitive map representations and can be readily transferred to the 'Checklist for Verbal Directional Responses' (Figure 2.3).

Other checklists

The layout for recording the following seven variables follow the same patterns and is based on Lynch's (1960) major organisational elements but modified by the researcher to include two additional elements. The children's verbal responses were recorded on their drawn cognitive map representations by the researcher, which can be transferred to the relevant columns on checklist (Figure 3.3) relating to the following variables:

1. The identification of features on the cognitive map representations
2. Children's environmental perception of the "Likes" of the test area.
3. Reasons for their "Likes"
4. Children's environmental perception of the "Dislikes" of the test area.
5. Reasons for their "Dislikes"
6 Large-scale Ordnance Survey map of the "test" areas.
7. Vertical aerial photograph of the "test" areas.

The inter- rater reliability check was undertaken by a second scorer who evaluated the interpretation of the checklists at a rating of 90%.

MODIFICATIONS TO THE STAGES OF DEVELOPMENT CHECKLIST

Over-lapping stages of development

As mentioned previously, the data arising from both pilot studies indicated that a substantial proportion of children were producing drawn cognitive map representations, which were assigned to over-lapping stages of development. During the interpretation and scoring of the main study children's drawn cognitive map representations, two observations were made and hypotheses were considered for the over-lap. The first hypothesis was that the concept of the continuity of route was incorrectly placed within the projective two stage on the checklist and the second hypothesis was that the concept of perspective was incorrectly placed within the projective one stage of development. As Table 3.3 shows, approximately 58% of the main study children's drawn cognitive map representations relating to Map Area A and approximately 70% relating to Map Area B, could not be placed into a definite developmental stage, but over-lapped at the projective one and projective two stages. The high percentage of over-lapping indicated the possibility that even at this late stage, modifications to the checklist relating to developmental stages may be required before the analysis of results was undertaken.

Table 3.3 Drawn cognitive map representations placed into over-lapping developmental stages.

Stages of development	Map Area A No.children	%	Map Area B No. children	%
Emergent	41	16.3	23	9.2
Topological	24	9.5	2	0.8
Projective 1	20	7.9	14	5.5
Over-lapping between projective 1 and 2	**147**	**58**	**196**	**77.8**
Projective 2	18	7.1	15	5.9
Euclidean	2	0.8	2	0.8

Concerning the concept of route at the projective two stage of development. Out of the 147 children's drawn cognitive map representations relating to Map Area A, which were placed at the over-lapping projective one/two stage, 39.73% of these children only depicted the concept of route and no other concepts at the projective two stage. Relating to Map Area B, 26.4% of the 196 children's drawn cognitive map representations only depicted the concept of route at the projective two stage. If these children had not identified the concept of route at the projective two stage, they would have been placed at the projective one stage of development. Relating to the concept of perspective, 40.41% of the children who were placed within the overlapping projective one/two stage relating to Map Area A identified every concept contained within the projective one stage of development, apart from the concept of perspective. The absence of this one concept stopped them from being placed in the projective two stage of development, because they had depicted other concepts within the projective two stage of development. The absence of the concept of perspective at the projective one stage was mirrored by 29.44% on the children's drawn cognitive map representations relating to Map Area B

The checklist for interpreting children's drawn cognitive map representations relating to developmental stages was manipulated into Table 3.4. This shows the number of cartographic concepts identified on the drawn cognitive map representations (expressed as a percentage) for each of the individual concepts by the 252 children involved in the sample. The emergent stage was not included because children at this stage had not identified any cartographic concepts on their drawn cognitive map representations. Table 3.4 explicitly illustrates the misplacement of the concept of 'route' at the projective two stage and the concept of 'perspective' at the projective one stage. A rank order table was constructed (Table 3.5) This was to establish if there was any justification for moving the concepts of 'route' and 'perspective' from one of the projective stages to another projective stage. Tables 3.4 and 3.5 showed that at the topological stage for both areas the concept of route was placed 1st in rank order. At the projective two stage, 156 out of the 252 children (approximately 62%) identified the concept of 'route' in Map Area A, and 204 of the 252 children (approximately 81%) in Map Area B, both being placed 4th in rank order.

Table 3.4 Possible misplacement of the concepts of route and perspective

	Map A	Map B
TOPOLOGICAL STAGE Does the route (arrow/ line that can be broken) start near the place indicated in the instructions?	82.73%	90.83%
PROJECTIVE ONE STAGE Are any roads or paths or pavements shown, in addition to the route?	56.35%	76.19%
Sufficient detail. Have at least eight features been identified? (Do not include discrete features)	32.14%	30.16%
Direction. Does the route (arrow or line) start at the child's home and finish at either Children's World or McDonalds? (Breaks in continuity accepted)	63.49%	84.13%
Orientation. Does the route (arrow or line) start at the child's home and finish at either Children's World or McDonalds? (Breaks in continuity accepted)	63.49%	84.13%
Perspective. Look at the OS map showing the route. Are there any features on the child's drawn cognitive map representation that the child cannot visually see, if he/ she walked the route?	**7.54%**	**7.14%**
PROJECTIVE TWO STAGE Plan form. Are any of the buildings in plan form?	24.60%	33.33%
Sufficient detail. Have more than eight features been identified on the map? (Do not include discrete features)	24.6%	21.03%
Perspective. Look at the OS map showing the route. Are there any features on the map that the child cannot see, if he/ she walked the route? Features must be connected by road.	3.97%	6.35%
Continuity of routes. Does route (arrow /line) start and finish as mentioned in researcher's instructions follow instructions (breaks not accepted)	**61.9%**	**80.95%**
Continuity of roads. Does road start and finish as mentioned in researcher's instructions follow instructions (breaks not accepted)	36.51%	57.94%
Improvement in direction. Does route follow the road/path, start and finish as mentioned in researcher's instructions (breaks not accepted and at least nine cartographic features identified)	15.87%	19.84%
Improvement in orientation. Does the route follow the road/path, start at the child's home and finish at either Children's World or McDonald's? (Breaks in continuity NOT accepted and at least nine cartographic features identified)	15.87%	19.84%
Distance. Is shape of map similar to route marked on OS map (same area)?	13.09%	5.95%
Scale. Is the shape of the child's map similar to the route marked on the OS map of the same area and are similar features the same size and shape?	8.73%	7.54%
EUCLIDEAN STAGE A true map. Is map in plan form and can it read and understood completely?	0.4%	0.4%
Does the map accurately show more details, than asked for in instructions? (At least thirteen features should have been identified. No discrete features)	4.76%	8.33%
Direction	4.76%	1.2%
Orientation	4.76%	1.2%
Distance	5.95%	0.8%
Scale	3.97%	1.2%
Shape	3.17%	0.8%
Size	3.97%	0.8%
Key. Does the map contain either a key, or are all features labelled	1.98%	0.4%
In addition, the following concepts were identified:		
Labelling	36.11%	66.27%
Title	0.4%	0%

Table 3.5 Rank order of cartographic concepts identified on children's drawn cognitive map representations relating to Map Areas A and B

	Scores for map area A	Scores for map area B
Route 1	211	229
Direction 1	160	212
Orientation 1	160	212
Route 2	156	204
road 1	142	192
road 2	92	146
detail 1	81	76
plan form 1	62	84
detail 2	62	53
Direction 2	40	50
Orientation 2	40	50
Distance 1	33	15
Scale 1	22	19
Perspective 1	19	18
Distance 2	15	2
detail 3	12	21
Direction 3	12	3
Orientation 3	12	3
Perspective 2	10	16
Scale 2	10	3
Size	10	2
Shape	8	2
Key	5	1
true map	1	1
Total number of concepts	1375	1614

Although the concept of 'perspective' was placed at the projective one stage within the checklist, it was only identified by 19 of the 252 children (approximately 7.5%) relating to Map Area A and by 18 of the 252 children (approximately 7%) relating to Map Area B, and placed 14th in rank order for both areas. These results support modifications to the checklist and the re-positioning (within particular stages of development) the concepts of route and perspective.

Two other cartographic concepts were included in the modification of the checklist; namely that of 'labelling' and the necessity to provide an element of development within the concept of 'plan form'. The two latter decisions were based on observations made during the marking of the initial checklist. Firstly, that some form of labelling was depicted on one-third of the children's drawn cognitive map representations relating to Map Area A and two-thirds relating to Map Area B. Yet this was not taken into consideration during the construction of the initial checklist. Although different forms of labelling such as names of roads and buildings were depicted on Catling's (1978) illustrated overview showing examples of map styles, labelling was not included within his stages and comments (Figure 1.3). It was the stage and comments part that was changed into questions producing a 'Yes' or 'No' answer and used in the construction of the checklist relating to stages of development. Labelling was not included in the initial checklist. Secondly, the definition for 'plan form' on the checklist was "Are any of the buildings in plan form?" this did not provide for any progression in development. For example, some children's drawn cognitive map representations included buildings depicted in both iconic and plan form. The checklist posed the question 'Are any of the buildings in plan form?' but an ambiguity arose. On the one hand, sixty-two children in the 'school' area and eighty-four children in the 'other' area identified 'some buildings' in 'plan form'. On the other hand, thirty-two children's drawn cognitive map representations relating to Map Area A and forty-four children's drawn cognitive map relating to Map Area B in the 'other' area identified 'all buildings' in 'plan form'. The checklist was modified and the concept of plan form question remained but was re-named plan form 1, and the concept of plan form 2, defined as "Are all the buildings in plan form?" was included in the revised checklist. The main changes in the modification to the checklist (Figure 3.10) relating to stages of development were that: -

1. 'Perspective 1' was transferred to projective two stage
2. Labelling was included at projective one stage
3. Continuity of roads (2) was transferred to projective one stage
4 Continuity of route (2) was transferred to projective one stage
5 Plan form was separated into plan form (1) and plan form (2)

The checklist (Figure 2.2) relating to cartographic concepts was also revised in order to include these modifications (Figure 3.11)

Figure 3.10 MODIFIED CHECKLIST RELATING TO STAGES OF DEVELOPMENT

Child number ____ Sex ____ Year group ____ School _______ Map Area_______

Developmental Stages/ Cartographic Concepts	Answer
EMERGENT STAGE Start at the Topological Stage. Does the child fulfil the requirements of the Topological Stage? If the answer is NO, the child is at the Emergent Stage	yes/no
TOPOLOGICAL STAGE Does the route (arrow/ line that can be broken) start near the place indicated in the instructions? If answer is NO, the child is at the Emergent stage.	yes/no
PROJECTIVE ONE STAGE Direction. Does the route (arrow or line) start and finish near the places indicated in the instructions? (Breaks in continuity accepted)	yes/no
Orientation. Does the route (arrow or line) start and finish near the places indicated in the instructions? (Breaks in continuity accepted)	yes/no
Continuity of routes. Does the route (arrow or line) start and finish near the places indicated in the instructions? (breaks in continuity NOT accepted)	yes/no
Are any roads or paths or pavements shown, in addition to the route?	yes/no
Labelling. Is there any evidence of labelling?	yes/no
Continuity of roads 2. Does the road start and finish near the places indicated in the instructions? (Breaks in continuity NOT accepted)	yes/no
Sufficient detail 1. Have at least eight features been identified? (Do not include discrete features)	yes/no
PROJECTIVE TWO STAGE Plan form 1. Are any of the buildings in plan form?	yes/no
Sufficient detail. Have more than eight features been identified on the map? (Do not include discrete features)	yes/no
Improvement in direction. Does the route follow the road/path, start and finish near the places mentioned in the instructions? (Breaks in continuity NOT accepted and at least nine cartographic features identified)	yes/no
Improvement in orientation. Does the route follow the road/path, start and finish near the places mentioned in the instructions? (Breaks in continuity NOT accepted and at least nine cartographic features identified)	yes/no
Plan form 2. Are all features in plan form?	yes/no
Distance 1. Is the shape of the child's map similar to the route marked on the OS map of the same area?	yes/no

Scale 2. Is the shape of the child's map similar to the route marked on the OS map of the same area and are similar features the same size and shape?	yes/no
Perspective 1. Look at the OS map showing the route. Are there any features on the map that the child cannot see, if he/ she walked the route? Features NOT connected by road.	yes/no
EUCLIDEAN STAGE Accurate and detailed. Does the map accurately show more details, than those asked for in the instruction? (At least thirteen features should have been identified. Do not include discrete features)	yes/no
Perspective 2. Look at the OS map showing the route. Are there any features on the map that the child cannot see, if he/ she walked the route? Features must be connected by road.	yes/no
Does it reasonably resemble the Ordnance Survey map of the area and the researcher's instructions? Are the following concepts roughly accurate and similar to the ORDNANCE SURVEY Map of the area?	yes/no
Direction	yes/no
Orientation	yes/no
Distance	yes/no
Scale	yes/no
Shape	yes/no
Size	yes/no
Key. Does the map contain either a key, or are all features labelled	yes/no
A true map. Is the map in plan form and can it be read and understood completely?	yes/no

The children's drawn cognitive map representations were re-marked using the revised checklists (Figures 3.10 and 3.11) and Table 3.6 shows the number of cartographic concepts (expressed as percentages) identified by two hundred and fifty two children. The modifications made to the checklist (Figure 3.10) eliminated the incorrect placing of the cartographic concepts of route and perspective as argued in the methodology. The emergent stage was not included in this table because children placed at this stage had not identified any cartographic concepts on their drawn cognitive map representations. Although Table 3.6 showed that there were differences in the number of children depicting particular cartographic concepts between Map Area A and Map Area B. The issue of over-lapping stages of development still existed. For example, using the data from the modified checklist, the percentage of children's drawn cognitive map representations relating the over-lapping stages of projective one and two was reduced to approximately 16% relating to Map Area A and approximately 17% relating to Map Area B.

Figure 3.11 Modified checklist relating to cartographic concepts

Developmental Stages/ Cartographic Concepts	
Topological Stage route (1) shown -- Projective One Stage direction (1) shown Orientation (1) shown continuity of route 2) roads (1) shown labelling continuity of roads (2) sufficient detail (1) --- Projective Two Stage some buildings in plan form (1) sufficient detail (2) improvement in direction (2) improvement in orientation (2) plan form (2) distance (1) scale (1) perspective (1) --- Euclidean Stage sufficient detail 3) perspective (2) direction (3) orientation (3) distance (2) scale (2) size shape key true map Other Title	

Table 3.6 Percentage of 252 children depicting cartographic concepts on their drawn cognitive map representations using the modified checklist

	Map A %	**map B %**
TOPOLOGICAL STAGE Does the route (arrow/ line that can be broken) start near the place indicated in the instructions	84%	91%
PROJECTIVE ONE STAGE Direction 1. Does the route (arrow or line) start and finish near the places indicated in the instructions? (Breaks in continuity accepted)	63%	84%
Orientation 1. Does the route (arrow or line) start and finish near the places indicated in the instructions? (Breaks in continuity accepted)	63%	84%
Continuity of routes 2. Does the route (arrow or line) start and finish near the places indicated in the instructions? (breaks in continuity NOT accepted)	62%	81%
Roads 1. Are any roads or paths or pavements shown, in addition to the route?	56%	76%
Labelling. Is there any evidence of labelling?	35.71%	67%
Continuity of roads 2. Does the road start and finish near the places indicated in the instructions? (Breaks in continuity NOT accepted)	37%	58%
Sufficient detail 1. Have at least eight features been identified? (Do not include discrete features)	32.14%	30%
PROJECTIVE TWO STAGE Plan form 1. Are any of the buildings in plan form?	25%	33%
Sufficient detail 2. Have more than eight features been identified on the map? (Do not include discrete features)	25%	21%
Improvement in direction 2. Does the route follow the road/path, start and finish near the places mentioned in the instructions? (Breaks in continuity NOT accepted and at least nine cartographic features identified)	16%	20%
Improvement in orientation 2. Does the route follow the road/path, start and finish near the places mentioned in the instructions? (Breaks in continuity NOT accepted and at least nine cartographic features identified)	16%	20%
Plan form 2. Are all features in plan form?	13%	17%
Distance 1. Is the shape of the child's map similar to the route marked on the OS map of the same area?	13%	6%
Scale 2. Is the shape of the child's map similar to the route marked on the OS map of the same area and are similar features the same size and shape?	9%	8%
Perspective 1. Look at route on OS map. Are there any features on the map that the child cannot see, if he/ she walked the route? Not connected by road	8%	7%
EUCLIDEAN STAGE Sufficient detail 3. Does the map accurately show more details, than asked for in the instruction? (At least 13 features - not including discrete features)	5%	8%
Perspective 2. Look at route on OS map. Are there any features connected by road, on the map that the child cannot see, if he/ she walked the route?	4%	6%
Direction 3	5%	1%
Orientation 3	5%	1%
Distance 2	6%	1%
Scale 2	4%	1%
Shape	3%	1%
Size	4%	1%
Key. Does the map contain either a key, or are all features labelled	2%	0

Different developmental stages between Map Areas A and B

The interpretation of the main study children's drawn cognitive map representations showed that approximately 47% of the children were producing drawn cognitive map representations which were assigned different stages of development between Map Areas A and B.(Table 3.7).

Tables 3.7 Children assigned to different stages of development between Map Areas A and B

	Number of children.	**Number of children expressed as %**
same stage	133	52.8%
one stage	59	23.4%
two stages	43	17.1%
three stages	10	4.0%
four stages	7	2.8%

Table 3.7 indicated a possible conflict between children's drawn cognitive map representations and the Piagetian perspective that implied children pass from one stage of development to the next. Although Piaget (1971 p10)) pointed out that the order of the stages is constant and sequential, he also suggested that an important problem for the theory of stages is that of time lags. At certain stages the child is able to solve problems in quite specific areas. But if one changes to another material or to another situation, even with a problem which seems to be closely related, lags of several months are noted, and in some cases even one or two years. Another problem was that although Piaget argued that each stage was necessary for the following one, he also proposed that some of the concepts contained within the stages of projective and Euclidean space developed in parallel and were mutually interdependent (Gerber 1981, Ottosson 1987). The problem for the researcher was whether to challenge or acknowledge the Piagetian perspective and at the same time consider the ambiguity of children's drawn cognitive map representations being placed at the different stages of development. It was important to resolve this problem prior to the presentation of the results as only one stage of development for each child would be required as the

dependent variable for some of the statistical testing. Yet an important criterion in the development of the instrument was the consideration of using two different but familiar areas. Therefore for the purpose of this research the checklists relating to stages of development were re-examined by considering the cartographic concepts identified by the children on their drawn cognitive map representations relating to Map Areas A and B. Because of the Piagetian perspective that children progress from stage to stage a decision was taken to use the higher stage of development achieved by the children. By using this method ten children were actually moved up one stage of development as a result of using the combination of the two map areas. Figure 3.12 is an example of a boy's marked checklist (only using 'Yes' answers) of how both drawn cognitive map representations, relating to Map Areas A and B, were placed at the over-lapping projective one / two stage of development. However, by using the 'Yes' answers for both drawn cognitive map representations this child demonstrated an understanding of all cartographic concepts contained within the projective one stage. In addition, he understood some cartographic concepts contained within the projective two stage of development. Therefore he was placed at the higher projective two stage of development. The procedure and methodology carried out in the main study showed that it was possible to use primary school children's cognitive map representations (drawn and verbal) to elicit their understanding of cartographic concepts and knowledge. The following chapter is concerned with the presentation and the analysis of the results taking into consideration the modifications addressed in this chapter relating to developmental stages.

Figure 3.12 Checklist (showing 'Yes' answers only) relating to Map Areas A and B

	Map A Stage	Map B Stage	Higher stage achieved
TOPOLOGICAL STAGE			
route 1	Yes	Yes	Yes
PROJECTIVE ONE STAGE			
Direction 1	Yes		Yes
Orientation 1.	Yes		Yes
Route 2.	Yes		Yes
Road 1	Yes	Yes	Yes
Labelling.		Yes	Yes
Roads 2.	Yes	Yes	Yes
Sufficient detail 1.		Yes	Yes
PROJECTIVE TWO STAGE			
Plan form 1.		Yes	Yes
Perspective 1	Yes		Yes
STAGE OF DEVELOPMENT	**Pro 1/2**	**Pro 1/2**	**Pro 2**

CHAPTER FOUR

THE PRESENTATION AND ANALYSIS OF THE RESULTS

The over-riding questions emerging from the search of the literature were "Can a method be developed as a means of measuring children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" For the purpose of this research the definition for the umbrella term of 'overall general mapping ability', embraces the following variables:

<u>drawn cognitive map representations relating to</u>

developmental stages of cognitive map representation

cartographic concepts depicted on cognitive map representations

cartographic features depicted on cognitive map representations

and

<u>verbal cognitive map representations relating to:</u>

directional responses

environmental perception responses

interpretation of large scale Ordnance Survey maps

interpretation of vertical aerial photographs

The procedures outlined in the methodology were followed and the data was collected. This was subjected to statistical analysis using the SPSS 10.0.5 for Windows 95/98/NT computer package. The results were examined mainly, by means of two-factor analysis of variance (year group x gender) for Map areas A, B and the combined map areas. Then to investigate the detail of any overall significant effect, post hoc Tukey HSD tests were performed. In addition, results relating to differences between Map areas A and B were examined by means of t-tests. The data and analysis of the results are presented in the first instance by looking at scores on each variable prior to combining the results of all variables in order to identify the 'overall general mapping ability' of primary school children. The first variable to be considered is concerned with stages of development.

THE STAGES OF DEVELOPMENT VARIABLE

The modified checklist (Figure 3.10) was used to interpret and record the results of primary school children's drawn cognitive map representations. It was used for the 'stages of development' variable and was constructed within a Piagetian paradigm and based on Catling's (1978) illustrated table and comments (Figure 1.3). The analysis of the main study results (as discussed in Chapter 3) showed that the spread of stages of development was more complex than either Piaget's (1955:1960) three stages (topological, projective and Euclidean), or Catling's (1978) four stages (topological, projective 1, projective 2 and Euclidean) stages of development. As Table 4.1 shows, because of 'overlapping' of stages, eight distinct developmental categories have been identified. The 'overlapping' of stages occurred because some children's drawn cognitive map representations showed evidence of the understanding of cartographic concepts contained in more than one stage of development.

Although the majority of the children taking part in the study (by the results of their drawn cognitive map representations) were placed at the projective 1 stage of development (developmental category 3), three issues emerged. Firstly, that 21.1% of the children's drawn cognitive map representations relating to Map Area A and 23.9% relating to Map Area B were placed at 'overlapping' stages of development (Table 4.1). Secondly, that approximately 47% of the children's drawn cognitive map representations were assigned different stages of development between Map Areas A and B (Table 3.6). Thirdly, that 16.3% of the children's drawn cognitive map representations relating to Map Area A and 9.1% relating to Map area B were placed into an emergent stage of development (developmental category 1) (Table 4.1). Each of these issues are addressed in the following sections.

Overlapping stages of development

The results of the initial checklist, as discussed in the previous chapter highlighted the high percentage of children's drawn cognitive map representations being placed at the over-lapping projective one/two stage of development (Table 3.2). This complexity was partially resolved by modifying the checklist and repositioning the concepts of perspective, route and road. For example, perspective (1) was transferred to projective two stage and the continuity of route (2) and roads (2) were transferred to projective one stage of development. The reasons for the repositioning of the cartographic concepts were based on the theoretical considerations discussed in Chapter 3. Table 3.4 showed the rank order (for both map areas) of the possible 27 concepts depicted on the children's drawn cognitive map representations, supporting the modifications to the checklist relating to developmental stages. However, the complexity of overlapping of stages still remained. Although the percentage 'over-lapping' at the projective one/two stage of development was reduced, two other 'over-lapping' stages emerged. As Table 4.1 shows, in addition to the 'over-lapping' projective one/two stage of development, a small percentage of children's drawn cognitive map representations 'over-lap' between the projective one/two/Euclidean and between the projective two/Euclidean stages of development.

Table 4.1 Children placed at each developmental category (shown as percentages)

Developmental categories	Stages of development	Map Area A %. (n = 252)	Map Area B % (n = 252)	Combined results of both map areas. % (n = 252)
Category 1	Emergent	16.3	9.1	6.7
Category 2	Topological	8.7	0.8	1.2
Category 3	Projective 1	45.2	54	50.4
Category 4	Projective 1 and 2	15.9	16.7	16.3
Category 5	Projective 2	7.9	10.7	13.1
Category 6	Pro/1/2/Euclidean	1.2	1.6	1.6
Category 7	Projective 2/Euclidean	4.0	5.6	7.9
Category 8	Euclidean	0.8	1.6	2.8

Different developmental categories between Map Areas A and B

The interpretation of the main study children's drawn cognitive map representations (Table 3.6) showed that approximately 47% of the children were producing drawn cognitive map representations, which were assigned different categories of development between Map Areas A and B. Roughly half of these drawn cognitive map representations showed a difference of one developmental category and a smaller proportion showed a difference of two developmental categories. The remainder (7%) showed a difference of either three or four developmental categories.

These observations are consistent with Piaget's (1971) argument that children respond differently when presented with problems framed in different contexts. Matthews (1984a pp91 -93) used two environments in his research, so as "to provide the potential for the full richness of environmental images to be recalled and represented". Matthews argued that children learn about different environments in different ways. When they are faced with a linear journey, the route itself becomes a well remembered construct, but when describing an area, such as around their home, spatial properties loom large in the minds of the young. Therefore, by providing two opportunities to demonstrate knowledge the children were given the opportunity to maximise their chance of optimum performance. It is their optimum performance that is taken as the indicator of their level of development.

Emergent stage of development

The findings, expressed as percentages (Table 3.2) showed that forty-one children (16%) relating to Map Area A and twenty-three children (9%) relating to Map Area B did not depict an understanding of any cartographic concepts on their drawn cognitive map representations. However, by considering what the children understood from both maps a different picture emerged. By using the higher stage achieved on their drawn cognitive map representations (as discussed in Chapter 3-part v) the percentage of children's drawn cognitive map representations being placed at the emergent stage of development was reduced to 6.7%. The reason that children were placed at the emergent stage of development (developmental category 1) was that they were unable to follow the researcher's instructions by depicting the particular feature on their drawn cognitive map representations that showed the start of the route. Depicting the start of the route on their drawn cognitive map representations was an important part of the instrument. Yet children placed at this stage do possess knowledge and understanding in some of the other mapping variables. As Blades et al's (1998) research indicated, mapping abilities are well developed by the age of four years and provide some evidence that mapping abilities emerge without training in very young children of all cultures. These results bring into question of whether the development of spatial cognition proceeds more rapidly than is claimed in Piagetian theory in that children younger than about seven are 'pre-operational', hence cannot perform the cognitive 'operations' involved in map-reading.

Relating to year groups

Table 4.1 illustrates that, when considering all children in the study, the majority of their drawn cognitive map representations were placed at the projective 1 stage of development. However, when considering the spread of the stages of development relating to the different year groups there were differences (Tables 4.2, 4.3 and 4.4). Although some children from each of the seven year-groups were placed at the projective 1 stage of development, the reception and Year 1 group of children dominated the emergent, topological and projective 1 stage of development and the Year 6 group of children dominated the Euclidean stage of development. The tables indicate a developmental pattern between the extreme age ranges and there appears to be progression relating to age through the stages. However, what has emerged is that most children across the age range are in the projective one stage of development and this links with Piaget's theory of intellectual development when children between the approximate ages of seven to eleven years are placed within the concrete operational stage.

Table 4.2 Children placed at developmental categories relating to year groups and Map Area A (shown as percentages)

Developmental categories	Stages of development	Rec. (%) N = 36	Year 1 (%) N = 36	Year 2 (%) N = 36	Year 3 (%) N = 36	Year 4 (%) N = 36	Year 5 (%) N = 36	Year 6 (%) N = 36
Category 1	Emergent	53	22	17	8	3	11	
Category 2	Topological	17	17	19	6	3		
Category 3	Projective one	31	61	50	69	47	42	17
Category 4	Pro. one/two			8	17	31	28	28
Category 5	Projective two			3		8	11	33
Category 6	Pro one/two/Euc					3	35	3
Category 7	Pro two/Euc			3		6	3	17
Category 8	Euclidean						3	3

Table 4.3 Children placed at developmental categories relating to year groups and Map Area B (shown as percentages)

Developmental categories	Stages of development	Rec. (%) N = 36	Year 1 (%) N = 36	Year 2 (%) N = 36	Year 3 (%) N = 36	Year 4 (%) N = 36	Year 5 (%) N = 36	Year 6 (%) N = 36
Category 1	Emergent	39	11	6	6		3	
Category 2	Topological	3	3					
Category 3	Projective one	58	83	89	58	50	33	6
Category 4	Pro. one/two		3	6	25	33	22	31
Category 5	Projective two				3	11	28	33
Category 6	Pro one/two/Euc				6		6	
Category 7	Pro two/Euc				3	8	8	19
Category 8	Euclidean							11

Table 4.4 Children placed at developmental categories relating to year groups and combined map areas (shown as percentages)

Developmental categories	Stages of development	Rec. (%) N = 36	Year 1 (%) N = 36	Year 2 (%) N = 36	Year 3 (%) N = 36	Year 4 (%) N = 36	Year 5 (%) N = 36	Year 6 (%) N = 36
Category 1	Emergent	33	3	3	6		3	
Category 2	Topological	3	3	3				
Category 3	Projective one	64	92	75	53	36	28	6
Category 4	Pro. one/two		3	14	25	42	19	14
Category 5	Projective two			3	8	8	33	36
Category 6	Pro one/two/Euc						8	3
Category 7	Pro two/Euc			3	8	14	6	25
Category 8	Euclidean						3	17

Table 4.5 shows the percentage of children's drawn cognitive map representations placed within each developmental category by gender for Map Areas A, B and the higher stage achieved by combining both map areas. These results could be interpreted as girls being superior to boys in their developing stages of drawn cognitive map representation. For example, there were fewer girls placed at developmental category one (emergent stage) and more girls' drawn cognitive map representations placed at developmental category eight (Euclidean stage of development). On the other hand, as Table 4.5 shows, there appears to be a close correlation between the percentage of girls and boys placed at developmental category three (projective 1 stage of development) for each of the areas. These results were inconsistent with Hart (1979) using large model maps or Matthews (1986)

using drawn cognitive map representations, which were both placed into three stages of development. Hart's results showed there were twice as many girls as boys placed at stage 1, slightly more boys than girls at stage 2, but at stage 3 there were twice as many boys as girls. This suggested that in 1973, boys were superior to girls in this particular test. Matthews (1986) supports Hart's results at stages one and two, but only boys were placed at stage 3, implying that boys were superior to girls. However, it was extremely difficult to make comparisons relating to Hart and Matthews results because of the introduction of an 'emergent stage of development' and the complexities of 'over-lapping' of stages. The results of possible gender differences relating to the eight development categories (stages of development) will be explored later in this chapter.

Although eight developmental categories have emerged, irrespective of age, the majority of children's drawn cognitive map representations were placed at the projective one stage of development (developmental category 3). A small percentage of children were placed at the extreme stages, for example, some children have not yet reached the projective stage, while other children are including aspects of Euclidean Space on their drawn cognitive map representations. However, at this stage it must be emphasised that it cannot be assumed that a measure on any one variable can be extrapolated to form a measure of general overall mapping ability.

Although using the checklist (Figure 3.10) to place children's drawn cognitive map representations into stages of development has highlighted complexities, the same checklist served two purposes. As well as placing children's drawn cognitive map representations into stages of development, the checklist also identified the possible understanding of twenty-seven separate cartographic concepts producing a quantitative score. The following section in this chapter addresses the cartographic concepts variable.

Table 4.5 Children placed at developmental categories relating to gender (shown as percentages)

		Girls % (n =126)	Boys % (n=126)
Developmental categories	Catling's stages of development		
	Map Area A		
Category 1	Emergent stage	12	21
Category 2	Topological stage	10	7
Category 3	Projective one stage	45	45
Category 4	Projective one/two stage	2	16
Category 5	Projective two stage	12	4
Category 6	Pro. one/two/Euclidean	1	2
Category 7	Projective two/Euclidean	3	5
Category 8	Euclidean stage	1	1
	Map Area B		
Category 1	Emergent stage	9	9
Category 2	Topological stage	1	1
Category 3	Projective one stage	52	56
Category 4	Projective one/two stage	17	7
Category 5	Projective two stage	14	7
Category 6	Pro one/two/Euclidean	1	2
Category 7	Projective two/Euclidean	4	7
Category 8	Euclidean stage	2	1
	Combined map areas		
Category 1	Emergent stage	6	8
Category 2	Topological stage	2	1
Category 3	Projective one stage	48	53
Category 4	Projective one/two stage	19	14
Category 5	Projective two stage	15	10
Category 6	Pro. one/two/Euclidean	0	3
Category 7	Projective two/Euclidean	7	9
Category 8	Euclidean stage	4	2

THE CARTOGRAPHIC CONCEPTS VARIABLE

The modified checklist used to place children's drawn cognitive map representations into stages of development (Figure 3.10) served two purposes. As well as placing children's drawn cognitive map representations into stages of development, the checklist also identified the understanding of individual cartographic concepts. The raw data relating to the understanding of a possible 27 cartographic concepts was transferred to checklist (Figure 3.11) for both Map Areas A and B. The numbers shown in brackets on Figure 3.11 depict elements of progression within particular concepts. For example, route (1) is placed at the topological stage of development, whereas the continuity of route (2) is placed at the projective one stage of development. Direction (1) and orientation (1) are placed at the projective one stage of development, but improvement in direction (2) and orientation (2) are placed at the projective two stage of development. The criterion for placing children at different stages of development for different cartographic concepts is highlighted in the questions producing 'Yes/No' answers, shown on Figure 3.10.

Although most research suggested that the areas around children's homes and their journey from home to school are familiar areas, these particular areas were not used in this research. It was considered that using the home to school area would give some children an unfair advantage because some children may live near to the school, while others may live up to three miles away. However, it might, on the one hand be expected that children living further away from the school had the opportunity to identify more cartographic concepts and features on their drawn cognitive map representations. But on the other hand these children may be travelling by car or other means of transport and only following the route in a passive manner and they could be at a disadvantage. Children living closer to the school may be walking or cycling and following the route in an active manner and could be at an advantage. Therefore, in order to ensure the instrument was generalisable to the population, the school perimeter route was used as one of the familiar areas (Map Area A), the other familiar area (Map Area B) being a route covering a distance of approximately three miles that was known and used by the children.

The results of t- tests for paired samples relating to all children in the study showed that the mean performance of children using Map area B was statistically significantly larger than the mean of Map area A relating to the following cartographic concepts. The numbers shown in brackets depict elements of progression within particular concepts: route (1) and (2), direction and orientation (1) and (2), road (1) and (2), detail (2) and (3), plan form (1) and (2), labelling. In contrast, the results were reversed when considering the cartographic concepts of distance (1) and (2). As shown on Table 3.5, the number of children depicted the concept of direction (1) and (2) on their drawn cognitive map representations relating to Map Area A were significantly larger than the mean performance of Map Area B.

When considering year groups, the cartographic concepts of road (1 and 2), route (2), direction and orientation (1) and labelling, dominated the earlier year groups, whereas the concepts of detail (2 and 3), direction and orientation (2) distance and plan form (1 and 2) dominated the older year groups.

Relating to the concept of labelling, the results are not consistent with Taylor's (1998) results, indicating that children under six-years of age failed to use labelling. The present study shows that reception children (five-year-old) depicted labelling on their drawn cognitive map representations relating to both map areas. Although the mean of Map area B was higher than the mean of Map area A, the result of a t-test for paired samples relating to the reception year group of children showed that the difference was not significant: $t= -1.963$, df 35, $p<0.058$.

The twenty-seven concepts contained within the stages of development variable (Table 3.5) were amalgamated to form the 'cartographic concepts variable' and the results of the testing indicated all children (252) taking part in the sample depicted more cartographic concepts on their drawn cognitive map representations for Map area B than for Map area A. The results of the t-tests (Table 4.6) showed that the differences were statistically significant for all children and all year groups (36 children), apart from Year group 2.

The results relating to all children in the study showed that children depicted more cartographic concepts on their drawn cognitive map representations relating to Map Area B against the Map Area A (Table 4.6). T-tests for paired samples were carried out to find out if the differences between the mean scores obtained by the children on their drawn cognitive map representations of Map Areas A and B was statistically significant. The results of the t-tests showed that differences were statistically significant in all cases except in Year group 2, although, even in this year group, there was a difference between Map area A (mean 4.31) and Map area B (mean 5.3). (see Table 4.6).

Although Map Area B was less familiar to the children than Map Area A, more cartographic concepts were depicted on Map Area B. Tentative reasons could be that the real life context (tell the driver the way to the swimming pool, Children's World or shopping precinct) triggered more engagement with the task of map-making than the story (tell Mickey Mouse the way to the playground). Or it could be that more cartographic features surrounded the children because the route covered a greater distance. However, at this stage, the reason was not an issue, the objective was to elicit as much cartographic knowledge as possible from the children's responses and one of the criteria in the construction of the instrument was the importance of including more than one familiar area. As Matthews (1984a, p91) suggested, using two environments "provides the potential for a full richness of environmental images to be recalled and represented". The result of the t-test provided some justification for using two different mapping areas as an important part of the instrument.

The results also indicated a developmental pattern between the mean scores obtained for the different year groups. (shown on Table 4.6) For example, the mean scores relating to Map Area A showed a range from 1.03 (reception year group) to 10.92 (Year group 6). The mean scores relating to Map Area B showed a range from 2.86 (reception year group) to 12.81 (Year group 6). However, the t-tests were only concerned with the differences between all children taking part in the main study, each year group and the two different map areas (Map areas A and B). A two factor analysis of variance (year groups x gender) relating to the number of cartographic concepts depicted on the drawn cognitive map representations was carried out, one for each of the two map areas (plus the combined map areas), in order to determine if the developmental and gender difference pattern were statistically significant.

Table 4.6 T-tests relating to number of cartographic concepts between Map Areas A and B

	Map Area A (mean)	**Map Area B (mean)**	**t test values for paired samples**	**d.f.**	**levels of sig.**
252 children in study	5.24	7.01	-7.86	251	***
YEAR GROUPS (36)					
Reception	1.03	2.86	-4.57	35	***
Year group 1	2.61	4.72	-4.23	35	***
Year group 2	4.31	5.31	-1.54	35	Ns
Year group 3	4.19	6.50	-4.49	35	***
Year group 4	6.72	7.78	-2.46	35	*
Year group 5	6.89	9.11	-3.05	35	**
Year group 6	10.92	12.81	-2.26	35	*

Key
*** p< 0.001
** p<0.01
* p<0.05
Ns p>0.05

Map area A

The results of the cartographic concepts variable examined by means of a two factor analysis of variance relating to Map area A, showed no significant effects for gender (F=2.687, d.f.=1, p>0.05), or for the non significant gender x class interaction (F=0.137, d.f.=6,p>0.05). There was a significant main effect for year groups (F=31.242, d.f.-6, p<0.001), and *post hoc* multiple comparisons (Tukey HSD (p<0.05) showed that when considering adjacent year groups only, the significant main effects were between:

Year group 3 (mean score 4.19) and Year group 4 (mean score 6.72)

Year group 5 (mean score 6.89) and Year group 6 (mean score 10.92).

Map area B

The results relating to Map area B showed no significant effects for gender (F=0.282, d.f.=1,p>0.05), or for the non significant gender x class interaction (F=0.740 d.f.=6,p>0.05). There was a significant main effect for year groups (F=40.59, d.f.=6, p<0.001), and *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that when considering adjacent year groups only, the significant main effects were between:

Year group 5 (mean score 9.11) and Year group 6 (mean score 12.81).

Combined map areas

The results relating to the combined map areas followed the same pattern as Map area B. showing no significant effects for gender (F=1.760, d.f.=1,p>0.05), or for the non significant gender x class interaction (F=0.302, d.f.=6,p>0.05). There was a significant main effect for year groups (F=50.323, d.f.=6, p<0.001), and *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that when considering adjacent year groups only, the significant main differences were between

Year group 5 (mean score 16.00) and Year group 6 (mean score 23.73).

The mean scores for Year group 5 for both Map areas A and B, plus the combined scores for both areas, was significantly lower than mean scores for Year group 6, thus showing a developmental pattern between the two adjacent year groups. Although there was a significant difference between Year group 3 and Year group 4 (for Map area A only), when combining the scores for Map area A and Map area B the effect was not significant (p=>0.053).

The results of the two factor analysis of variance (year groups x gender) relating to the number of cartographic concepts depicted on the drawn cognitive map representations , showed there were no effect for either gender or gender x year group interaction for each of the three map areas. When considering the significant effects for year groups the mean scores for Year group 5 for each of the three map areas was significantly lower than mean scores for Year group 6, thus showing a developmental pattern between the two adjacent year groups. Although there was a significant difference between Year group 3 and Year group 4 (for Map area A only), when combining the scores for Map area A and Map area B the effect was not significant. It was not possible to relate the results of the combined 'cartographic concepts' variable to other research, because to date there does not seem to have been an attempt to find a general measure. In this research, twenty-seven cartographic concepts were tested and amalgamated to form the cartographic concepts variable

CARTOGRAPHIC CONCEPTS AND STAGES OF DEVELOPMENT

As mentioned in the previous part of this chapter, the decisions about stages of development into which children were placed on the 'type' of concepts depicted on their drawn cognitive map representations. But placing children into stages of development did not identify the number of cartographic concepts (within each stage of development) that were depicted by the children. For example, it was possible that not all of the cartographic concepts contained within one particular stage of development were depicted on the children's drawn cognitive map representations, while at the same time, some of the cartographic concepts from the following stage were identified. The checklist relating to stages of development showed that the maximum number of cartographic concepts possible for children to depict for either Map area A or Map Area B at each stage of development was:

emergent stage	0
topological	1
projective one	8
projective two	16
Euclidean	27

or that the maximum number of cartographic concepts possible for children to depict for the combined map areas at each stage of development was:

emergent stage	0
topological	2
projective one	16
projective two	32
Euclidean	54

Figure 4.1 is a graph showing the mean number of cartographic concepts depicted on the drawn cognitive map representations relating to the combined map areas and placed within each stage of development.

Figure 4.1 Graph showing mean number of cartographic concepts relating to the combined map areas and stages of development

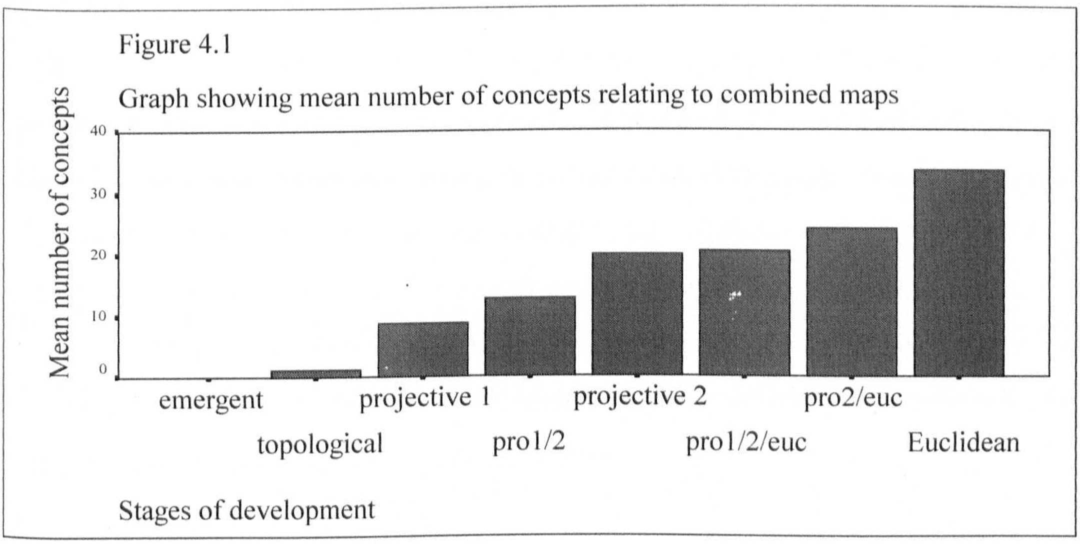


Table 4.7 showing mean number of cartographic concepts relating to Map Areas A and B and stages of development.

Stage of development	Possible number	Map Area A Mean score	Map Area B Mean score
emergent	0	0	0
Topological	1	1	1
Projective one	8	4.7	5.71
Projective one/two	Overlap	7.08	7.64
Projective two	16	11.95	12.00
Projective 1/2/Euc	Overlap	10.33	10.00
Projective 2/Euc	Overlap	16.40	15.57
Euclidean	27	22.00	21.00

Apart from the 'over-lapping' projective one/two/Euclidean stage, the data displayed on Table 4.7 indicates a developmental pattern. For example, the higher mean number of concepts depicted on the children's drawn cognitive map representations, the higher the stage of development achieved by the children. The exception being that children placed at the over-lapping stage of projective one/two/Euclidean stage of development for both Map Areas A and B understood less cartographic concepts on their drawn cognitive map representations than children placed at the projective two stage of development. This seems to suggest that the projective one/two/Euclidean 'overlap' is less well developed than the projective two stage of development. Both the graph and table highlighted the complexities of placing children's drawn cognitive map representations into stages of development. For example, individual cartographic concepts are contained within particular stages of development and the understanding of these concepts on children's drawn cognitive map representations determines each child's stage of development. One of the problems is that it does not give a clear picture of which cartographic concepts children understand. However, until the results of each of the variables contained within the umbrella term of 'overall general mapping ability' were addressed, any hypotheses or questions were not considered.

Examples of drawn cognitive map representations illustrate each of the different stages of development shown on Table 4.1. For convenience, the examples relate to School 1 and Map Area A only. Figure 2.15 shows a section of a large-scale Ordnance Survey map depicting the route and cartographic features mentioned in the researcher's instructions to the children.

<u>THE EMERGENT STAGE</u>

Figure 4.2 is an example of a Year group 3 boy's drawn cognitive map representation placed at the emergent stage of development because he was unable to follow the researcher's instructions to depict certain features on his drawn cognitive map representation and to draw a route starting at the main school gate. Had he followed these instructions he would have been placed at the topological stage of development, which is the starting point for the understanding of cartographic concepts ultimately leading to the Euclidean stage of development. Although his drawn cognitive map representation relating only to the cartographic concepts variable was placed at the emergent stage of development, this was only one the variables contained within the definition for the umbrella term of 'overall general mapping'. Therefore it cannot be

assumed that a measure on any one variable can be extrapolated to form a measure of overall general mapping ability. As Spencer et al (1989) suggested, caution is needed when recording children's responses because failure to utilize appropriate methods has often led to the underestimation of children's ability.

The Year group 3 boy's drawn cognitive map representation illustrates that he had the ability to show his understanding and knowledge within the other variables. For example, he had the ability to correctly identify features on a vertical aerial photograph and large-scale Ordnance Survey map of Map area A. He was also able to give verbal directional and environmental perception responses

<u>THE TOPOLOGICAL STAGE</u>

The topological stage is the first of Piaget et al's (1956; 1960) three stages of development in the construction of Euclidean space. Catling (1978) and Weigand (1993) stated that at this stage, children up to about the age of seven years are highly egocentric and features on their drawn cognitive map representations are pertinent to the experience of the children and any features without meaning to them are ignored. Table 4.1 shows that 8.7% of the children's drawn cognitive map representations relating to Map Area A and 0.8% of the children's drawn cognitive map representations relating to Map Area B were placed within the topological stage of development. The wide difference in the results between the two areas reinforces the justification for considering more than one area. It also implies that two issues are inter-relating at the same time, some children being affected by their development in particular cartographic concepts, and at the same time, their knowledge of the different large-scale environments also plays a part. This stage is important in that it shows that some of the younger children are able to follow instructions. They are able to depict their understanding of the cartographic concept of route on their drawn cognitive map representations. The topological stage is the starting point for the understanding of cartographic concepts. Figure 4.3 is an example of a Reception girl's drawn cognitive map representation placed at the topological stage of development because she followed the researcher's instructions and depicted the start of the route at the gate. Although only one cartographic concept was depicted on her

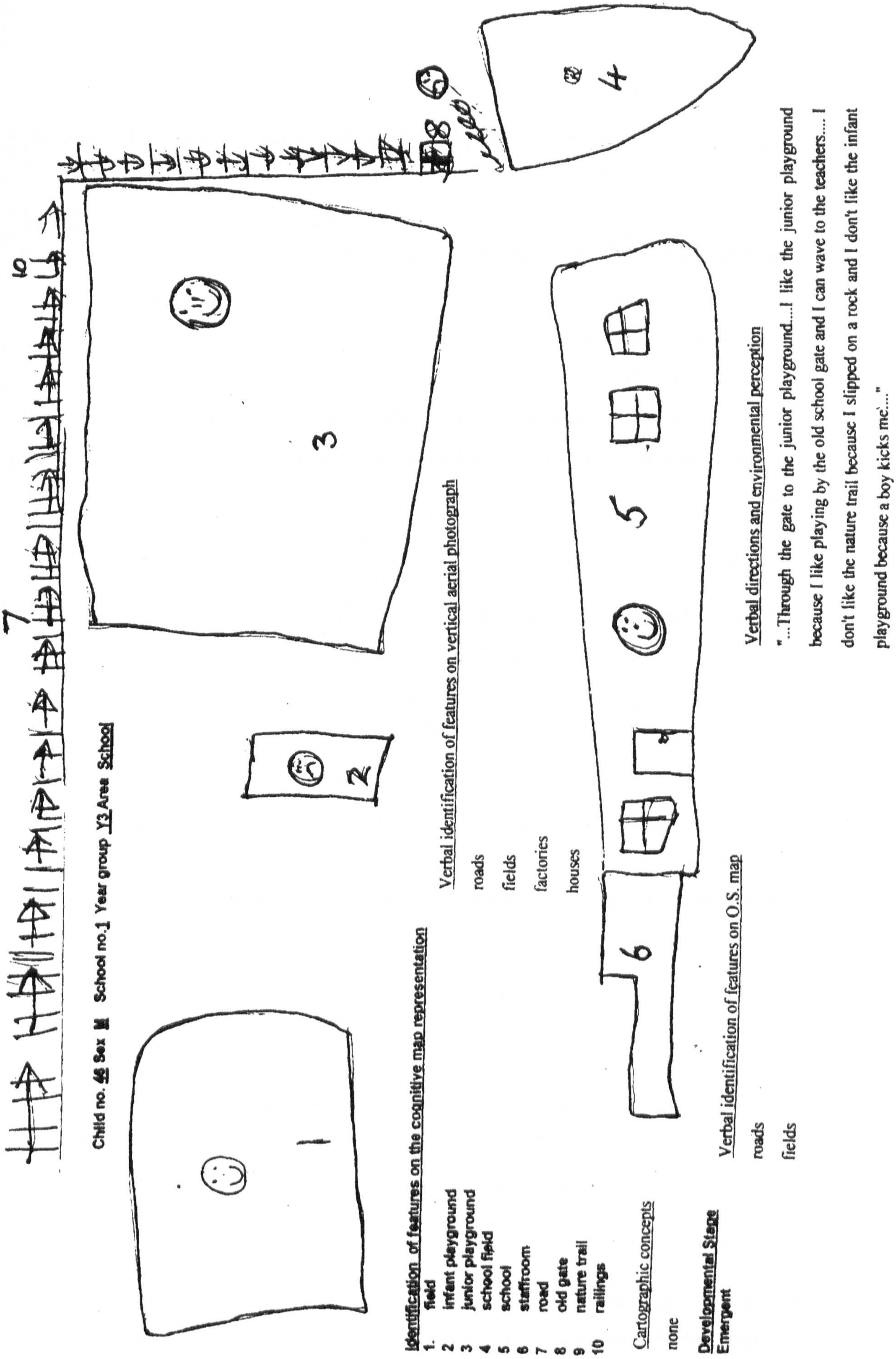


Figure 4.2 Year group 3 boy placed at the emergent stage of development.

drawn cognitive map representation, other cartographic responses from the combined variables were illustrated on her map relating to Map area A.

THE PROJECTIVE ONE STAGE

By the age of seven years, children have usually reached a stage of development in which their topological representation of the world becomes 'projective' (Piaget 1955, Catling 1978, Weigand 1993). They are now learning to decentre themselves or think in abstract (Donaldson 1978) and they can begin to imagine a route in their minds from different viewpoints and recreate their images onto paper as a map. This is because their understanding of the concepts of angles and area are beginning to emerge. This is the main and most important difference between projective space and the topological relationships. However, at the same time, children are also beginning to use some Euclidean concepts, (Piaget et al 1956; 1960, Beard 1969, Barker 1974, Weigand 1993). The majority of primary school children are placed within Piaget's projective stage. Although Catling (1978) refined Piaget's projective stage into two stages of cognitive map representations, namely, a projective one stage and a projective two stage, the results shown on Table 4.1 shows that the majority of primary school children taking part in the study were now being placed within the projective one stage of development. For example, 45.2% of the children's drawn cognitive map representations relating to Map Area A and 54% of the children's drawn cognitive map representations relating to Map Area B were placed at this stage of development. Figure 4.4 is an example of a year group 3 girl's drawn cognitive map representation placed at the projective one stage of development because she followed the researcher's instructions by depicting the start of the route at the gate and included a road. The possible number of cartographic concepts that could have been depicted was 8 and the mean score obtained by the children taking part in the study was 4.7. Only two cartographic concepts were depicted on the Year group 3 girl's drawn cognitive map representation relating to Map area A.

OVERLAPPING PROJECTIVE ONE /TWO STAGE

Although Catling (1978) refined Piaget's projective stage into two stages of cognitive map representations, some of the children's drawn cognitive map representations could not be placed into a definite stage of development but overlapped at the

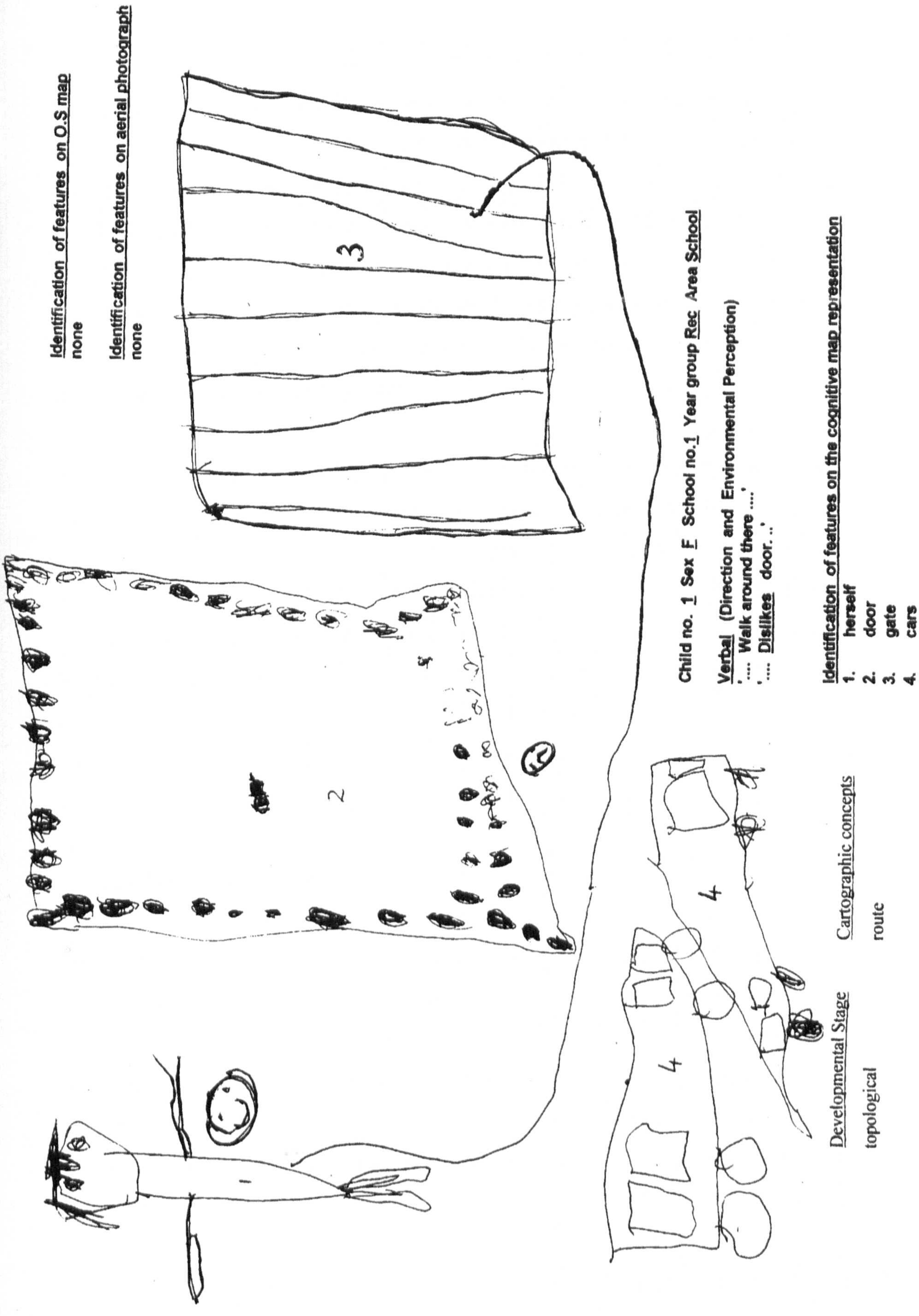


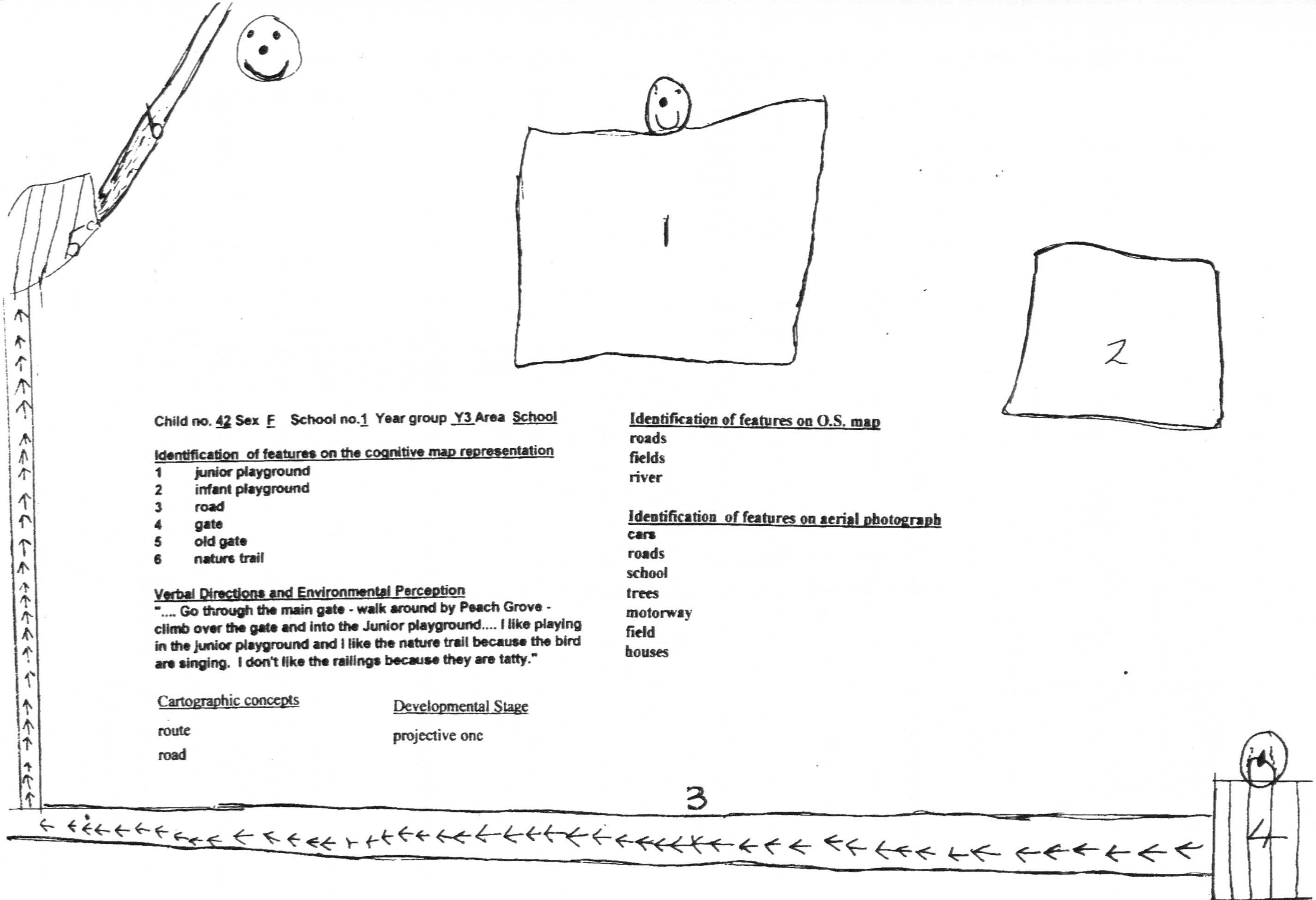
Figure 4.3 Reception girl placed at the topological stage of development

projective one and projective two stages. The reason being that although they did not have the ability to understand all the cartographic concepts contained within the projective one stage, they demonstrated an understanding of some of the cartographic concepts contained within the projective two stage. Table 4.1 showed that 15.9% of the children's drawn cognitive map representations relating to Map Area A and 16.7% relating to Map Area B were placed at the over-lap of the projective one and projective two stages of development. This over-lapping calls into question whether Piaget's projective stage should have been divided into a projective one and projective two stages of development.

Figure 4.5 is an example of a Year group 3 boy's drawn cognitive map representation placed at the overlapping projective one/two stage of development. Although he depicted an understanding of most of the cartographic concepts contained within the projective one stage, he did not depict an understanding of the continuity of roads or labelling. On the other-hand, he depicted an understanding of the concepts of plan form 1 and 2, sufficient detail and perspective 1 contained within the projective two stage of development. The mean score obtained by the children taking part in the sample at this over-lapping stage was 7.8. Ten cartographic concepts were depicted on the Year group 3 boy's drawn cognitive map representation.

<u>PROJECTIVE TWO STAGE</u>

Table 4.1 indicates that twenty children's (7.9%) drawn cognitive map representations relating to Map Area A and twenty-seven children's (10.7%) drawn cognitive map representations relating to Map Area B were placed within Catling's projective two stage of development. Figure 4.6 is an example of a Year group 6 boy's drawn cognitive map representation placed at the projective two stage of development. He depicted an understanding of all cartographic concepts contained within both the projective one and projective two stages of development, apart from the cartographic concept of perspective one. The mean score obtained by the children taking part in the sample at the projective two stage relating to Map area A was 11.95. Fifteen cartographic concepts were depicted on the Year group 6 boy's drawn cognitive map representation



Child no. 42 Sex F School no.1 Year group Y3 Area School

Identification of features on the cognitive map representation

1 junior playground
2 infant playground
3 road
4 gate
5 old gate
6 nature trail

Verbal Directions and Environmental Perception

"…. Go through the main gate - walk around by Peach Grove - climb over the gate and into the Junior playground…. I like playing in the junior playground and I like the nature trail because the bird are singing. I don't like the railings because they are tatty."

Cartographic concepts

route
road

Developmental Stage

projective onc

Identification of features on O.S. map

roads
fields
river

Identification of features on aerial photograph

cars
roads
school
trees
motorway
field
houses

Figure 4.4 Year group 3 girl placed at the projective one stage of development

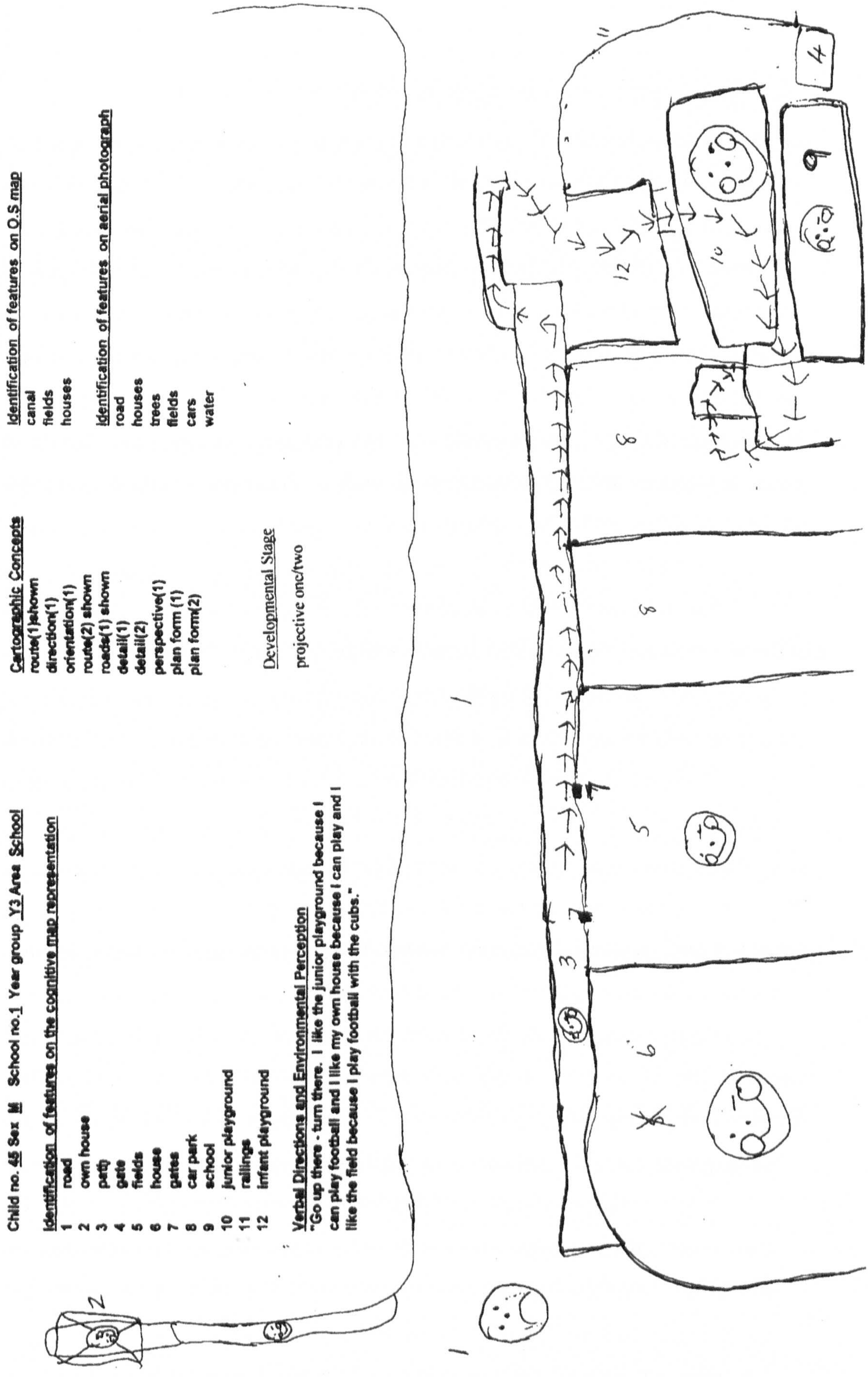


Figure 4.5 Year group 3 boy placed at the over-lapping projective one / 2 stage of development

OVERLAPPING BETWEEN PROJECTIVE ONE/TWO/EUCLIDEAN STAGE

Although Piaget argued that each stage was necessary for the following one, he also stated that some of the concepts contained within the stages of projective and Euclidean space developed in parallel (Gerber 1981, Ottosson 1987). This over-lapping is reflected on Table 4.1. For example, three (1.2%) children's drawn cognitive map representations relating to Map Area A and four (1.4%) children's drawn cognitive map representations relating to Map Area B were placed at the over-lapping projective one/two/Euclidean stage of development. When combining the results of both map areas, four children were placed at this stage. The data showed that these children were unable to show an understanding of the concepts of either labelling or detail (1) at the projective one stage, but each of these children did show an understanding of the concept of perspective (2) at the Euclidean stage. It is difficult to know whether this stage is either more or less advanced than the projective two stage, because the children placed within the projective two stage had identified all cartographic concepts contained within the projective one stage of development. Children at this stage are not able to depict an understanding of some of the cartographic concepts contained within the projective one stage of development, yet at the same time, they have mastered some of the cartographic concepts at the Euclidean stage of development. Figure 4.7 is an example of a Year group 4 girl's drawn cognitive map representation placed at the overlapping projective one/two/Euclidean stage of development relating to Map area A. On the one hand she was unable to depict an understanding of the cartographic concept of road 2 at the projective one stage; on the other hand, she was able to depict an understanding of the cartographic concept of perspective 2 at the Euclidean stage of development. The mean score obtained by the children taking part in the sample at this 'over-lapping' stage relating to Map area A was 10.33 and ten cartographic concepts were depicted on the Year group 6 boy's drawn cognitive map representation. These responses are less than those depicted by children at the projective two stage and raises questions concerning the possibility of using the stages of development variable as a measure of children's general mapping ability. As Weigand (1993) argued, although a sequence of development has been established, there is no agreement that children do pass through such stages.

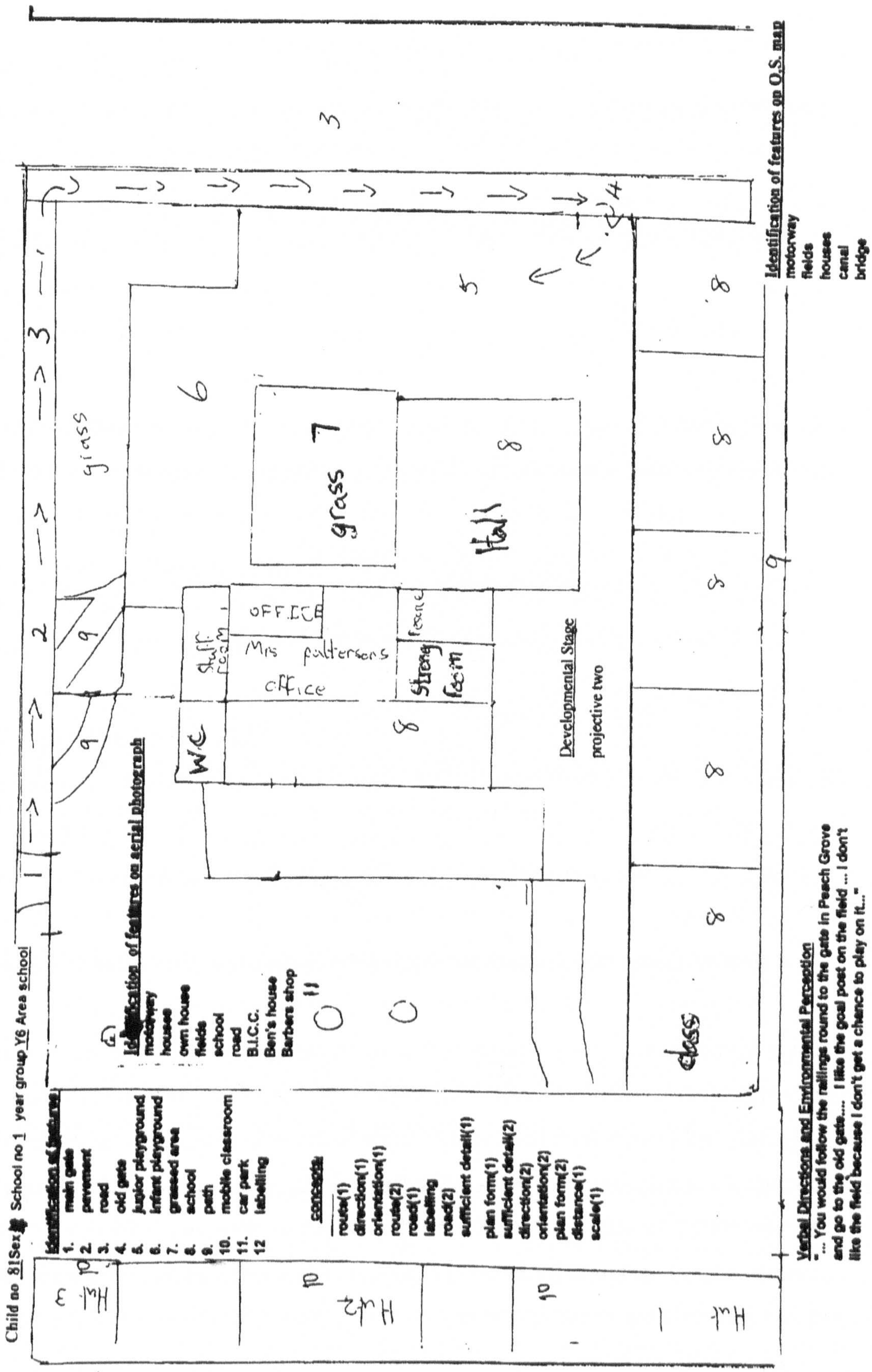


Figure 4.6 Year group 6 boy placed at the projective two stage of development

OVERLAPPING PROJECTIVE TWO/EUCLIDEAN STAGE

Table 4.1 shows that ten children (4%) of the drawn cognitive map representations relating to Map Area A and fourteen children (5.6%) of the drawn cognitive map representations relating to Map Area B were placed at the over-lapping stages of projective two and Euclidean stages of development. Figure 4.8 is an example of a Year group 3 boy's drawn cognitive map representation placed at the overlapping projective two/Euclidean stage of development. He was unable to depict an understanding of the cartographic concepts of plan form 2, scale 1 and perspective 1 at the projective two stage of development, but was able to depict an understanding of the concepts of detail 3, direction 3, orientation 3 and a key or complete labelling. The mean score obtained by the children taking part in the sample at this over-lapping stage of projective two/Euclidean relating to Map area A was 16.4 and eighteen cartographic concepts were depicted on the Year group 3 boy's drawn cognitive map representation

THE EUCLIDEAN STAGE

The Euclidean Stage emerges when children have progressed from the 'ego-centric' to the 'abstract' stage, and this usually occurs at about the ages of ten and eleven years of age (Piaget et al. 1956; 1960, Catling 1978, Gerber 1981, Weigand 1993). Table 4.1 shows that two (0.8%) of the children's drawn cognitive map representations relating to Map Area A and four (1.6%) of the children's drawn cognitive map representations relating to Map Area B were placed at the Euclidean stages of development. Figure 4.9 is an example of a Year group 5 girl's drawn cognitive map representation placed at the Euclidean stage of development because she depicted an understanding of all cartographic concepts contained within the checklist relating to the topological, projective one, projective two stage of development and all but one of the cartographic concepts contained within the Euclidean stage of development. Although a title was included within the checklist it was not included on her drawn cognitive map representation relating to Map area A. The mean score obtained by the children taking part in the sample at the Euclidean stage of development was 22. Twenty-six cartographic concepts were depicted on the Year group 5 girl's drawn cognitive map representation.

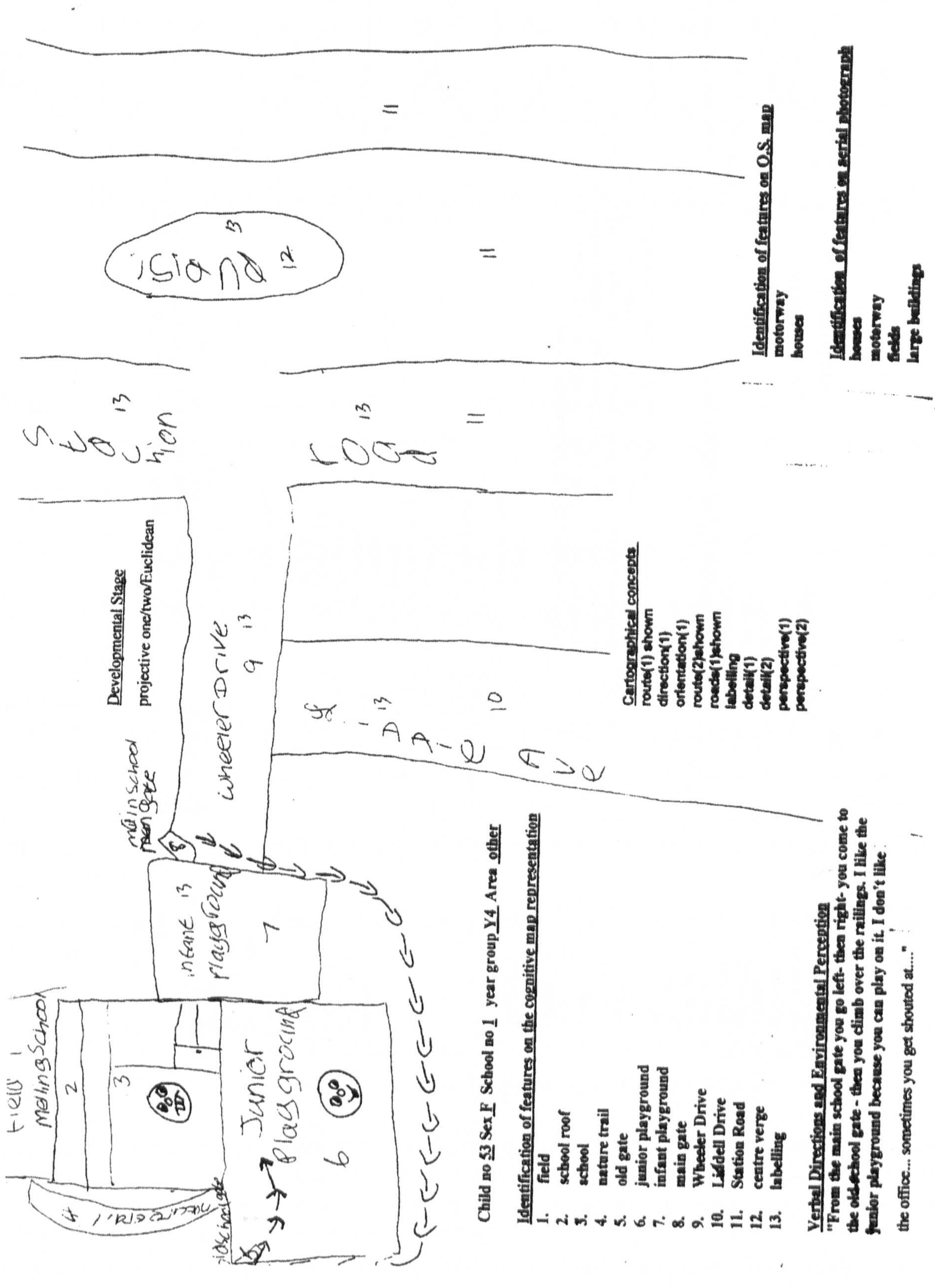


Figure 4.7 Year group 4 girl placed at the over-lapping projective one/two/Euclidean stage of development

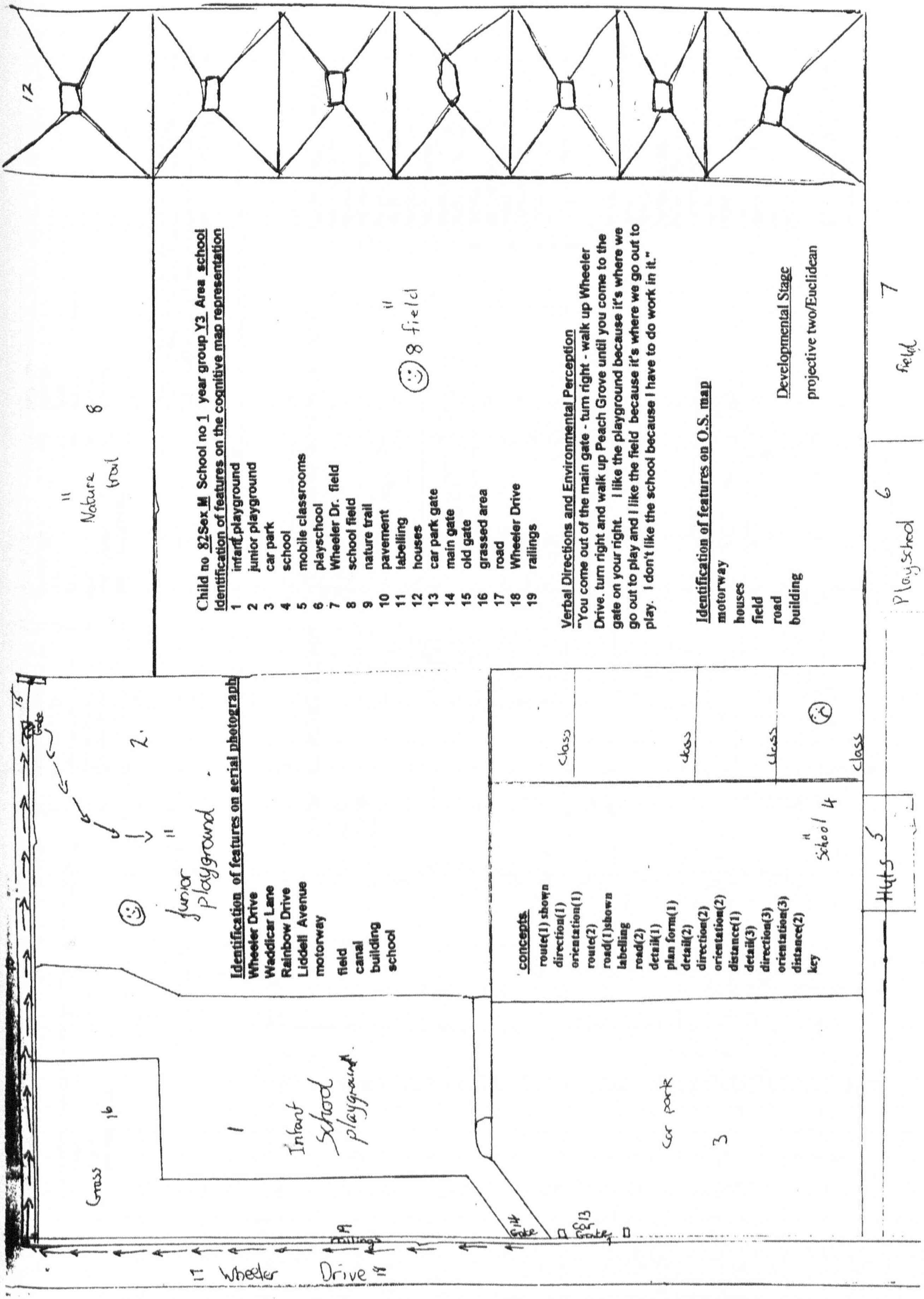


Figure 4.8 Year group 3 boy placed at the over-lapping projective two/Euclidean stage of development

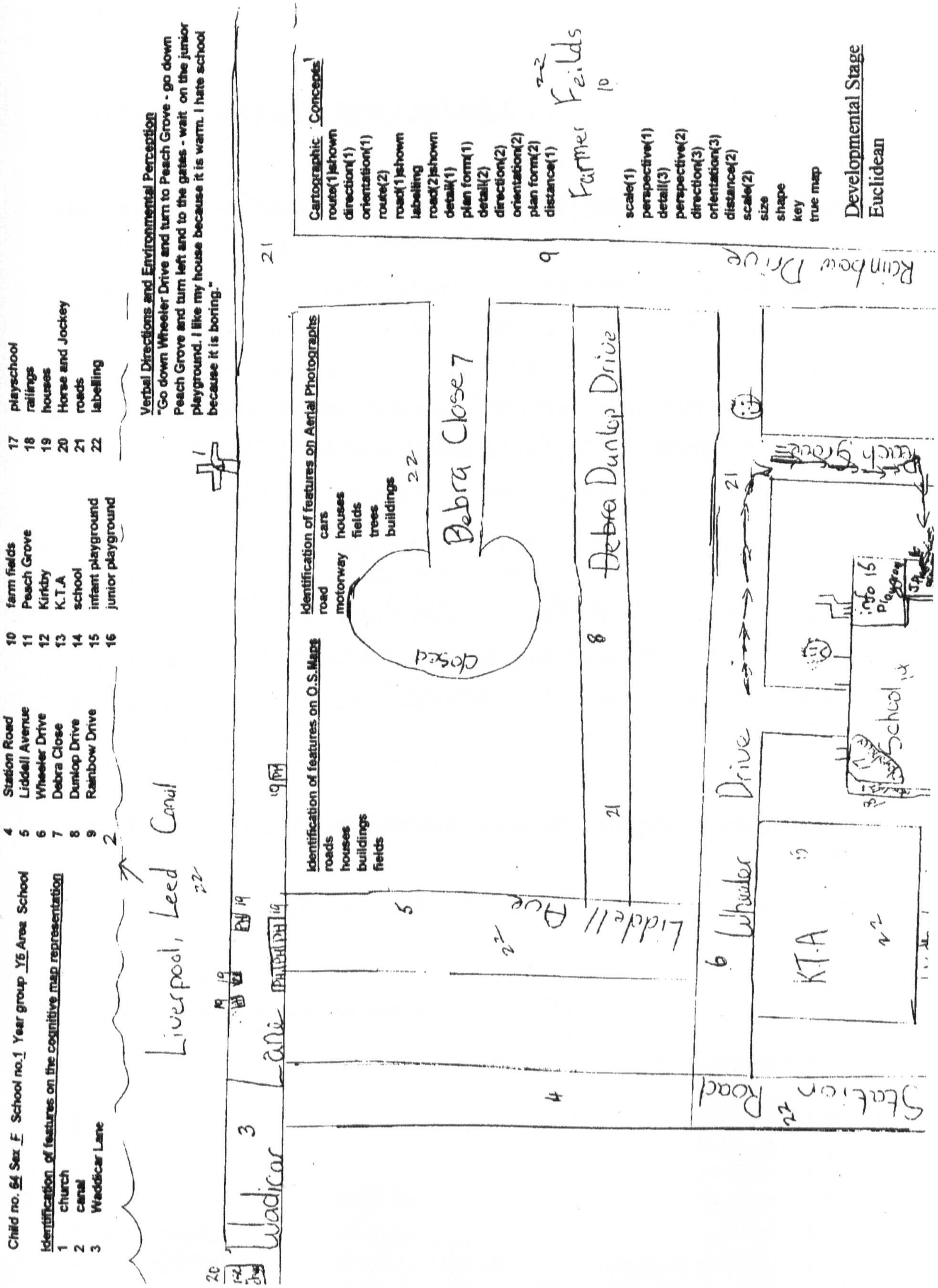


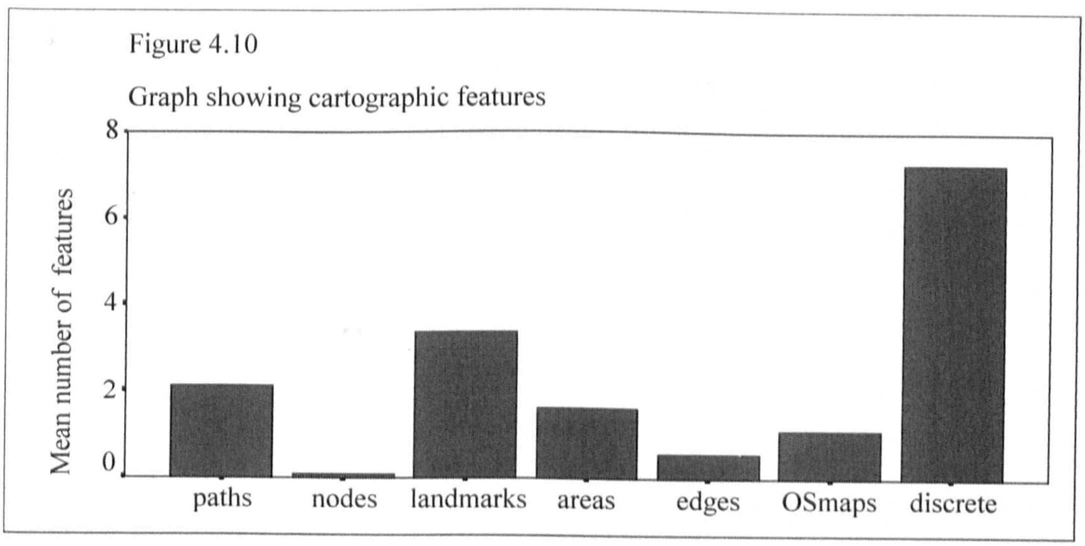
Figure 4.9 Year group 5 girl placed at the Euclidean stage of development.

CARTOGRAPHIC FEATURES VARIABLE

Lynch's (1960) five major organizational elements provided an objective method for recording the cartographic features depicted on drawn cognitive map representations. Two additional organisational elements were included in the checklist used for recording purposes in this research (Figure 3.3). The Ordnance Survey map and discrete features elements were included in order to accommodate features such as road names, railway embankments, 'the sandy slope' and 'the bus-stop'. Although features such as these were depicted on children's drawn cognitive map representations, they were not catered for in any of Lynch's (1960) five organisational elements of paths, nodes, landmarks, area and edges.

Prior to testing for statistical significance, a graph (Figure 4.10) was constructed showing the distribution of cartographic features depicted on 252 children's drawn cognitive map representations for the combined map areas and placed into organisational elements. The graph highlights the importance of 'discrete' features to primary school children.

Figure 4.10 Graph showing distribution of cartographic features (combined map areas)



In order to obtain an overall picture of primary school children's mapping ability relating to cartographic features, the scores obtained within each of the seven organisational elements were combined. Table 4.8 shows that when considering all children taking part in the main study there was a statistically significant difference between the number of cartographic features depicted on the children's drawn cognitive map representations relating to Map area A (mean 9.58) and Map area B (mean 8.80), t-value 2.96, d.f.=251, $p<0.01$. The mean scores for each of the stratified year groups (36 children) follow the same pattern (in the main), as for all children taking part in the sample, but the differences were only statistically significant at Year groups 1 and 4. More features were identified for Map Area A than Map Area B with one exception to this pattern. The exception was at Year group 6, when the mean score for Map Area B (13.67) was slightly more than Map area A (13.39), but the difference was not statistically significant.

Table 4.8 Results of t-tests for related samples relating to cartographic features between Map Areas A and B

	Map area A (mean)	**Map Area B (mean)**	**t-value**	**d.f**	**Significance**
252 children	9.58	8.80	2.96	251	**
Year groups (36)					
Reception	6.06	5.97	0.17	35	Ns
Year 1	7.44	6.64	2.11	35	*
Year 2	8.75	7.47	1.86	35	Ns
Year 3	9.50	8.97	0.67	35	Ns
Year 4	11.11	8.42	6.15	35	***
Year 5	10.78	10.44	0.46	35	Ns
Year 6	13.39	13.67	-0.26	35	Ns

Key
*** p< 0.001
** p<0.01
* p<0.05
Ns p>0.05

The data were also examined by means of two factor analysis of variance (year group x gender) relating to the cartographic features variable), one for each of the map areas (Map area A, B and the combined map areas). Then to investigate the detail of any overall significant effect, *post hoc* multiple comparison Tukey HSD tests were performed.

Map area A

The results of the cartographic features variable examined by means of a two factor analysis of variance relating to Map area A, showed no significant effects for gender (F=2.813, d.f.=1, p>0.05), or for the non significant gender x class interaction (F=0.172, d.f.=6, p>0.05). There was a significant main effect for year groups (F=17.685, d.f.=6, p<0.001), and when considering adjacent year groups only, *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant main effects were between:

Year group 5 (mean 10.78) and Year group 6 (mean 13.39).

Map area B

The results of the cartographic features variable examined by means of a two factor analysis of variance relating to Map area B, showed no significant effects for gender (F=2.266, d.f.=1, p>0.05), or for the non significant gender x class interaction (F=0.416, d.f.=6,p>0.05). There was a significant main effect for year groups (F=15.563, d.f.=6, p<0.001), and), and when considering adjacent year groups only, *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant main effects were between:

Year group 5 (mean score 10.44) and Year group 6 (mean score 13.67).

Combined map areas

The results of the cartographic features variable examined by means of a two factor analysis of variance relating to the combined map areas showed no significant effects for gender x year group interaction (F=0.095, d.f.=6, p.>0.05).There was a significant main effect for year groups (F=22.254, d.f.=6, p<0.001), and *post hoc* multiple comparisons (Tukey HSD (p<0.05)showed when considering adjacent year groups only, the significant effects were between:

Year group 5 (mean score 20.94) and Year group 6 (mean score 27.06).

There was also a significant effect for gender (F=4.276, d.f.=1, p<0.04).

The results of the two factor analysis of variance indicates a developmental pattern between Year groups 5 and 6, the mean score of Year group 6 children being significantly greater than the mean score of Year group 5 children for each of the three tests carried out. There were main effects between other year groups, but in order to determine if a developmental pattern existed, only adjacent year groups were considered. For example, any significant differences between extreme year groups, such as between reception and Year group 6 children would be expected but not taken into consideration.

These results show the opposite from the 'cartographic concepts' variable when more concepts were depicted on the drawn cognitive map representations relating to Map area B than Map area A. It could be speculated that children depicted more discrete features on their drawn cognitive map representations relating to Map area A because this area was more familiar to them, but on the other hand, the route to Map area B covering a greater distance gave the children the opportunity to depict their understanding of cartographic concepts. This supports further the decision to test more than one familiar area and address each of the variables contained within the umbrella term of 'overall general mapping ability'.

When considering gender differences between all girls and boys (and year groups), although the mean scores for girls were higher than boys for the combined map areas, the results of t-tests (Table 4.9) showed that the differences were not statistically significant.

However, the results of the two factor analysis of variance showed that there was a significant effect for gender .In order to determine where the gender differences occurred a one factor analysis of variance (gender within year groups) was carried out. The results for the combined map areas showed ($F= 10.644$, d.f=13, $p<0.001$). By considering same and adjacent year groups only, the *post hoc* multiple comparisons Tukey HSD ($p<0.05$) results showed significant differences between Year group 5 boys (mean 19.67) and Year group 6 girls (mean 27.28).

Table 4.9 results of t-tests for independent samples relating to cartographic features between girls and boys and combined map areas.

	Girls (mean)	**Boys (mean)**	**t-value**	**df**	**Significance**
252 children	19.12	17.47	1.695	250	Ns
Year groups (36)					
Reception	12.67	11.39	.986	34	Ns
Year 1	14.72	12.89	1.189	34	Ns
Year 2	17.11	15.39	.961	34	Ns
Year 3	19.33	17.56	.782	34	Ns
Year 4	20.50	18.56	.869	34	Ns
Year 5	22.22	19.67	1.183	34	Ns
Year 6	27.28	26.83	.147	34	Ns

Key

Ns $p>0.05$

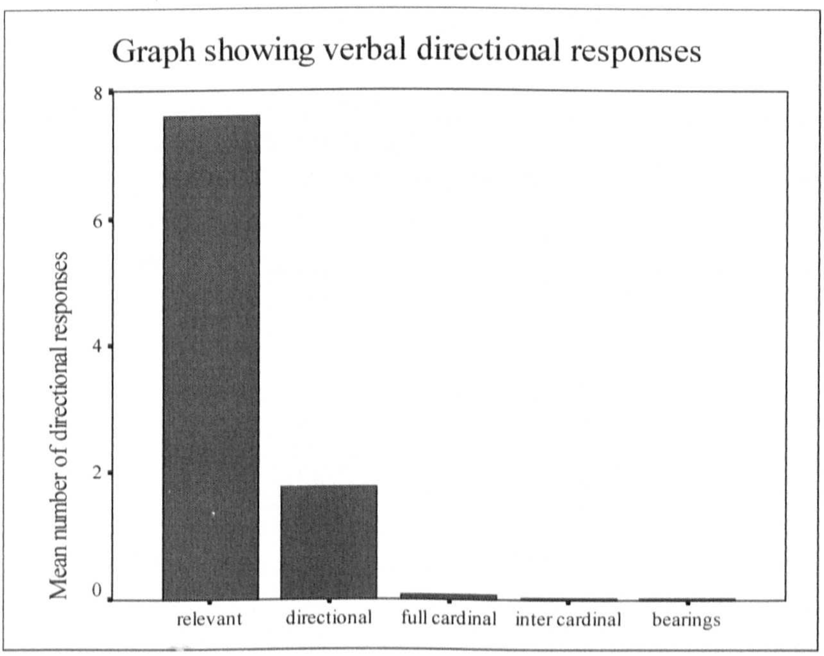
These results were inconsistent with Wickstead (1991) in that the girls in Year groups 2, 5 and 6 identified more cartographic features than boys; the Year groups 3 and 4 boys identified more cartographic features than girls relating to Map area A. Relating to Map area B, apart from the Year group 2 girls, the other year groups identified more cartographic features than boys. They are also inconsistent with Matthews (1984c) results suggesting that before eight years of age there were only slight differences in gender, but from the age of eight, gender differences were most evident. Boys' maps were consistently better than girls' maps showing more detail. Although the results are inconsistent with O'Laughlin and Brubaker's (1998) results indicating that there were no apparent gender differences in the final performance on selected navigational type tasks, it is difficult to make comparisons, because their research involved college students and differences between year groups was not an issue.

The 'stages of development', 'cartographic concepts' and 'cartographic features' variables were concerned with features depicted on the drawn cognitive map representations. The two following variables were concerned with verbal responses relating to these features.

VERBAL DIRECTIONAL VARIABLE

The construction of the checklist (Figure 2.3) used to record verbal directional responses was based on Harrison and Harrison's (1989) four stages of progression starting with directional language such as 'near' and 'far', 'left' and 'right', progressing to full cardinal points, intermediate cardinal points and finally bearings. A pre-stage labelled 'relevant language' was included to accommodate children's responses such as " go that way" and "then you're there". The data from the completed checklists was stored on SPSS and prior to testing for statistical significance a graph was constructed to show an overall picture. The graph (Figure 4.11), illustrates the distribution of verbal directional responses relating to the route depicted on children's drawn cognitive map representations relating to both Map areas A and B.

Figure 4.11 Graph showing number and type of verbal directional responses (combined map areas)



It explicitly shows that 81.5% of the children's verbal directional responses were included in the 'relevant language' stage and therefore justifies the inclusion of this stage within the checklist and as part of the instrument. The 'directional' stage of progression included 18.5% of the children's verbal responses, but the other three stages of progression only included about 1% of the children's responses relating to the 'full cardinal directions' stages of progression and hardly any responses were made for the 'intermediate cardinal directions' and 'bearings' stages of progression. This is consistent with Blades and Medlicott's (1992) research concerned with the ability to give route directions from a map and involving four groups of children (6, 8, 10, and 12 years) and one group of adults. They indicated that although cardinal direction was included in their testing it was rarely used by any age group.

The scores obtained within each of the five stages of progression were combined in order to produce to the 'verbal directional responses' variable. The results of t-tests (Table 4.10) showed that the differences between Map area A and B were statistically significant for all children and all year groups apart from the reception year group. Overall, children offered more responses relating to Map area B than Map area A (Table 4.10). These results are consistent with Wickstead's (1991) research indicating that more verbal directional responses were made by the sample as a whole relating to the McDonald's map area than for the school and its perimeter map area.

Table 4.10 Results of t-tests for paired samples between mean number of verbal directional responses and Map areas A and B

	Map Area A (mean)	**Map Area B (mean)**	**t-value**	**d.f**	**Significance**
252 children	4.06	5.38	-8.553	251	***
Year groups (36)					
Reception	2.14	2.72	-1.721	35	Ns
Year 1	3.19	4.08	-2.652	35	*
Year 2	4.03	4.86	-2.289	35	*
Year 3	4.11	5.78	-4.044	35	***
Year 4	4.69	5.61	-2.133	35	*
Year 5	4.94	6.56	-3.783	35	**
Year 6	5.31	8.03	-6.072	35	***

Key
*** $p < 0.001$
** $p<0.01$
* $p<0.05$
Ns $p>0.05$

The data were also examined by means of two factor analysis of variance (year group x gender) relating to the verbal directional responses variable), one for each of the map areas (Map area A, B and the combined map areas). Then to investigate the detail of any overall significant effect, *post hoc* multiple comparison Tukey HSD tests were performed.

Map area A

The results of the 'verbal directional responses' variable examined by means of a two factor analysis of variance relating to Map area A, showed no significant effects for gender (F=1.005, d.f.=1, p>0.05), or for the non significant gender x class interaction (F= 1.215, d.f.=6, p>0.05). There was a significant main effect for year groups (F=17.461, d.f.=6, p<0.001), and when considering adjacent year groups only, *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant main effects were between: By considering adjacent year groups only, the results of the post hoc tests showed that the significant differences only existed between extreme year groups and did not indicate a developmental pattern between the year groups.

Map area B

The results of the 'verbal directional responses' variable relating to Map area B, showed no significant effects for gender (F=0.225, d.f.=1, p>0.05). There was a significant main effect for year groups (F=20.782, d.f.=6, p<0.001), and when considering adjacent year groups only, *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant main effects only existed between extreme year groups and did not indicate a developmental pattern between. The results of the gender x year group interaction showed significant main effects:
F=2.201, d.f.=6, p<0.44). In order to determine where gender difference occurred, a one-factor analysis of variance (gender within year groups) relating to the verbal directional responses variable was implemented. The results showed a main effect:
F=10.625, d.f.=13, p<0.001, By considering the same and adjacent year groups only, the results of *post hoc* multiple comparisons (Tukey HSD) showed a significant difference ((p<0.05). between Year group 5 boys (mean score 6.28) and Year group 6 girls (mean score 8.89).

Combined map areas

The results relating to the combined map areas showed no significant effects for gender ($F=0.288$, d.f.=1, $p>0.05$), or for the non significant gender x class interaction ($F=1.841$, d.f.=6, $p>0.05$). There was a significant main effect for year groups ($F=6.031$, d.f.=6, $p<0.001$), and when considering adjacent year groups only, *post hoc* multiple comparisons (Tukey HSD ($p<0.05$), showed that the significant differences only existed between extreme year groups and did not indicate a developmental pattern between the year groups.

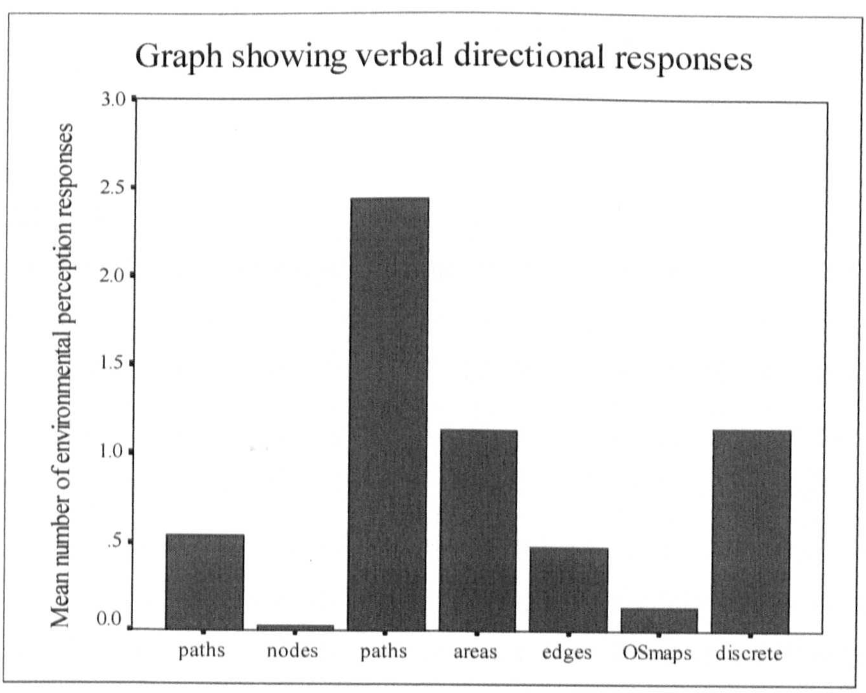
These results, concerning the gender issue, are similar to the results relating to the 'cartographic features' variable mentioned in the previous section of this chapter. In both variables, the Year group 6 girls' mean score was significantly greater than Year group 5 boys' mean score. The results relating to gender differences are consistent with Blades and Medlicott's research (1992) in that there was no evidence that the male subjects performed better than the female subjects.

The 'environmental perception' variable discussed in the following section is also concerned with features depicted on children's drawn cognitive map representations.

ENVIRONMENTAL PERCEPTION VARIABLE

The 'verbal environmental perception' variable was included within the umbrella term of 'general mapping ability' because when constructing drawn cognitive map representations of familiar areas, we think about certain features in both a cognitive and affective way. We not only think about what is there, but also, how we feel about these places (Siegel 1982, Golledge 1999). In order to elicit this affective element of information relating to the drawn cognitive map representations, one-to-one discussions, between the researcher and the children took place. The checklist (Figure 3.3) was used for recording children's verbal responses and the raw data were stored on SPSS. Prior to testing for statistical significance, a graph (Figure 4.12) was constructed showing the distribution of verbal environmental perception responses relating to features depicted on 252 children's drawn cognitive map representations for the combined map areas into organisational elements. The graph explicitly shows that landmarks play the most important part in children's feelings about familiar areas.

Figure 4.12 Graph showing distribution of verbal environmental perception responses. (combined map areas)



The scores obtained within each of the seven organisational elements were combined to give an overall score. Table 4.11 shows that when considering all children taking part in the main study and year groups (apart from Year groups 2 and 4) more verbal environmental perception responses were made relating to features depicted on their drawn cognitive map representations for Map Area B than for Map Area A. However, the results of the t-tests indicated that there were only significant differences at Year groups 1 and 4.

Table 4.11 Results of t-tests for paired samples between mean number of verbal environmental perception responses (Map Areas A and B).

	Map area A (mean)	**Map Area B (mean)**	**t-value**	**d.f**	**Significance**
252 children	2.84	3.04	-1.76	251	Ns
Year groups (36)					
Reception	1.25	1.69	-1.90	35	Ns
Year 1	2.11	2.67	-2.31	35	*
Year 2	2.83	2.81	0.11	35	Ns
Year 3	3.42	3.61	-0.54	35	Ns
Year 4	3.61	3.33	1.18	35	*
Year 5	3.19	3.64	-1.16	35	Ns
Year 6	3.47	3.56	-0.22	35	Ns

Key
* $p<0.05$
Ns $p>0.05$

Map area A

The results of the environmental perception variable examined by means of a two factor analysis of variance (gender x year groups) relating to Map area A, showed no significant effects for gender (F=0.443, d.f.=1, $p>0.05$), or for the non significant gender x class interaction (F= 0.552, d.f.=6, $p>0.05$). There was a significant main effect for year groups (F=9.333, d.f.=6, $p<0.001$), but when considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD ($p<0.05$), showed that the significant differences only existed between extreme year groups and did not indicate a developmental pattern between the year groups.

Map area B

The results relating to Map area B, showed no significant effects for gender (F=0.273, d.f.=1, p>0.05), or for the non significant gender x class interaction (F= 1.092, d.f.=6, p>0.05). There was a significant main effect for year groups (F=7.433, d.f.=6, p<0.001), but when considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant differences only existed between extreme year groups and did not indicate a developmental pattern between the year groups.

Combined map areas

The results relating to the combined map areas, showed no significant effects for gender (F=0.007, d.f.=1, p>0.05), or for the non significant gender x class interaction (F= 1.005, d.f.=6, p>0.05). There was a significant main effect for year groups (F=11.914, d.f.=6, p<0.001), but when considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that the significant differences only existed between extreme year and random indicating that there was no evidence of a developmental stage.

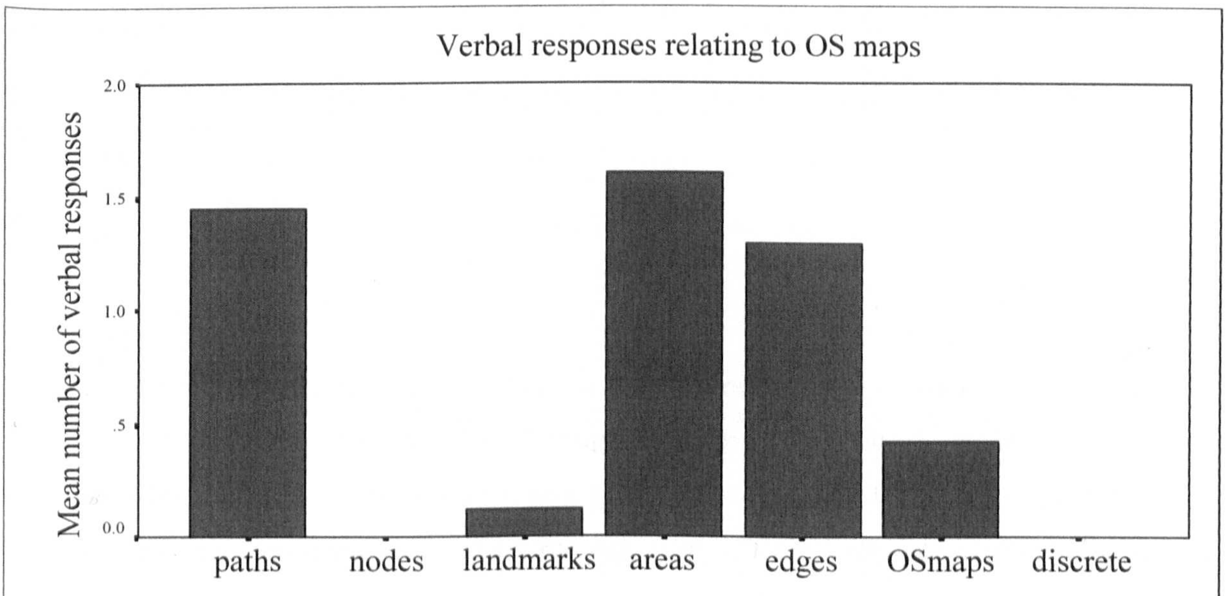
The results showed that there were no main effects between gender and these results are inconsistent with Hart's (1979) findings, which showed that when considering all children, boys gave more responses than the girls. Although his results showed that overall the boys gave more responses (52% of the total responses) than the girls (48%), the gender difference was minimal. However, when the children's responses were divided into two age groups by gender, the first group (Kindergarten to Grade 3) showed that the boys gave more responses than the girls (60% of the total responses) and the other group (Grade 4 to Grade 7) showed that the girls gave more responses (56% of the total responses) than the boys.

Although, part of Joshi et al's (1999) research was concerned with children's perceptions of the environment and involved children between seven and eleven years of age, it was difficult to make comparisons because the research questions were different and tests were not being replicated. Their results indicated that pollution (noise and/or smells) was negatively mentioned by 70% of the children and feelings of traffic danger by 68% of the children. The most disliked place was the towpath by an industrial canal by 56% of the children and the most favoured place was the path through the wood, chosen by 63% of the children.

LARGE SCALE ORDNANCE SURVEY MAP VARIABLE

Sections of large-scale Ordnance Survey maps depicting of the same familiar areas as the children's drawn cognitive map representations were used by the children in order to identify cartographic features. Their correct verbal responses were recorded on the checklist (Figure 3.3) and the raw data stored on SPSS. Graph (Figure 4.13) shows the number of children's verbal responses relating to the identification of large scale Ordnance Survey map features and recorded into seven organisational elements. The graph indicated that the 252 children taking part in the sample identified more paths, areas and edges than any of the other organisational elements.

Figure 4.13 Graph showing the distribution of verbal responses relating to large scale Ordnance Survey maps (combined map areas)



The scores obtained within each of the seven organisational elements were combined and t-tests for paired sample were carried out. Table 4.12 indicated that although children verbally identified more features on the large scale Ordnance Survey map relating to Map Area A (mean score 2.52) than Map Area B (mean score 2.37), the results of the t-test indicated that the difference was not statistically significant. However, the pattern changed when considering the stratified samples of year groups (36 children in each year group). The results were statistically significant for Year groups 3 and Year 6. At Year group 3 the children made more verbal responses relating to Map area B (mean score 2.64) than for Map area A (mean score 2.19), whereas at Year group 6 the situation was reversed as the children made more verbal responses relating to Map area A (mean score 5.42) than for Map area B (mean score 4.69).

Table 4.12 Results of t-tests for paired samples relating to large scale Ordnance Survey maps and Map Areas A and B

	Map area A (mean)	**Map Area B (mean)**	**t-value**	**d.f.**	**Significance**
252 children	2.52	2.37	1.60	251	Ns
Year groups (36 chd)					
Reception	0.42	0.44	-0.19	35	Ns
Year 1	1.25	1.06	1.07	35	Ns
Year 2	1.83	1.67	0.70	35	Ns
Year 3	2.19	2.64	-2.02	35	*
Year 4	3.22	3.33	-0.55	35	Ns
Year 5	3.33	2.75	1.71	35	Ns
Year 6	5.42	4.69	2.02	35	*

Key

* $p<0.05$
Ns $p>0.05$

Map area A

The results of the Ordnance Survey map variable examined by means of a two factor analysis of variance (gender x year groups) relating to Map area A, showed no significant effects for the gender x year group interaction (F= 0.873, d.f.=6, p>0.05). There was a significant main effect for year groups (F=39.469, d.f.=6, p<0.001), but when considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD (p<0.05), showed that differences between adjacent year groups showing a developmental pattern were between Year group 5 (mean score 3.33) and Year group 6 (mean score 5.42).This pattern between Year group 5 and Year group 6 is consistently occurring within the separate variables, the mean score of the older year group being significantly greater than the mean score of the younger year group. There was also a significant main effect for gender (F=4.710, d.f.=1, p<0.031 In order to determine in which year groups the gender differences occurred, a one factor analysis of variance test (gender within year groups) was carried out

(F=18.982, d.f.13, <p0.001. By considering same and adjacent year groups only, the results of the *post hoc* multiple comparisons (p<0.05) showed significant gender differences were between Year group 5 girls (mean 2.78) and Year group 6 boys (mean 5.94).

<u>Map area B</u>

Relating to Map area B and the Ordnance Survey map variable, the results showed no significant effects for gender (F=0.195, d.f.=1,p>0.05)or for the gender x year group interaction (F= 0.100, d.f.=6, p>0.05). There was a significant main effect for year groups (F=45.436, d.f.=6, p<0.001). and *post hoc* multiple comparisons Tukey HSD (p<0.05), showed that the differences between adjacent year groups were:

Year group 2 (mean 1.67) and Year group 3 (mean 2.64).

Year group 5 (mean 2.75) and Year group 6 (mean 4.69).

The results indicate that when considering Map area B, the developmental pattern is more pronounced than that for Map area A as four out of the seven year groups show a significant developmental pattern

<u>Combined map areas</u>

Relating to the combined map areas, the results showed no significant effects for gender (F=2.271, d.f.=1,p>0.05)or for the gender x year group interaction (F= 0.228, d.f.=6, p>0.05). There was a significant main effect for year groups (F=53.435, d.f.=6, p<0.001). and *post hoc* multiple comparisons Tukey HSD (p<0.05), showed that the significant differences between adjacent year groups were:

Year group 3 (mean score 4.83) and Year group 4 (mean score 6.56).

Year group 5 (mean score 6.08) and Year group 6 (mean score 10.03).

The results indicate that when combining the mean scores for both map areas, although the significant difference between Year groups 5 and 6 remains constant, the significant difference has changed from between the Year group 2 and 3 children (relating to Map area B) to between Year group 3 and 4 children when combining the mean scores for both Map areas A and B. A tentative reason is that it is probably to do with children thinking in different ways again supporting the notion that more than one familiar area should be used (Matthews, 1984a).

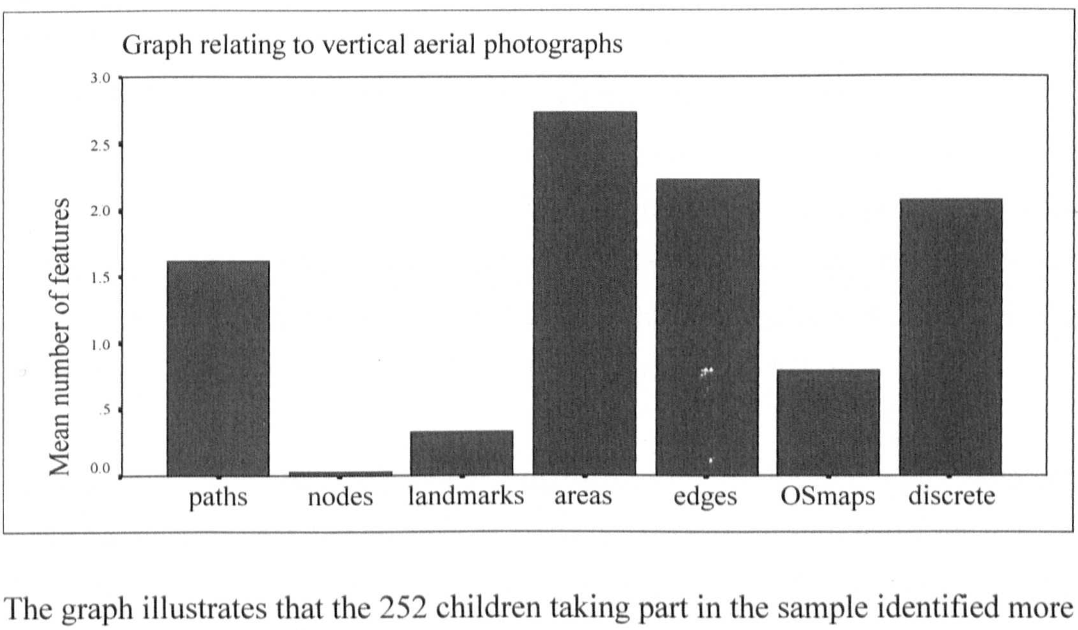
Relating to gender, the results of the t-tests indicated that there were no statistically significant differences between the number of features correctly identified by the girls and Map areas A and B. When considering all boys in the study and Year group 6 boys, the mean of Map area A was significantly higher than the mean of Map area B. These results were consistent with Matthews' (1987) results relating to the boys but not the girls. Matthews' results showed that both boys and girls identified more features on their home area maps (the more familiar area) than on their journey to school maps (the less familiar area) The results of the present study relating to the girls were not consistent with Matthews (1987) because the difference was not statistically significant.

The results of the testing relating to gender differences between Map areas A and B indicated that any differences were not statistically significant. These findings are inconsistent with Matthews' (1987) results showing that (relating to the journey to school) the seven, eight and ten year old boys (Year groups 2, 3 and 5) identified more features than the girls, but the six year old girls (Year 1) identified more features than the boys. Relating to the home area test, apart from the six and eight year old girls (Year groups 1 and 3), the boys in the other five year groups identified more than the girls. From these results Matthews suggested that boys were superior to girls in this particular general mapping variable.

VERTICAL AERIAL PHOTOGRAPHS VARIABLE

Procedures followed for the 'vertical aerial photographs' variable were identical to those followed for the 'large scale Ordnance Survey maps' variable. However, children were interpreting features depicted in a plan form on the large-scale Ordnance Survey maps, whereas in this variable the children were interpreting features depicted in an iconic form. The vertical aerial photographs were approximately the same scale as the large-scale Ordnance Survey maps and the photographs and maps were of the same familiar areas as the children's drawn cognitive map representations. Graph (Figure 4.14) shows the number of children's verbal responses relating to the identification of vertical aerial photograph features and recorded into seven organisational elements.

Figure 4.14 Graph showing the distribution of verbal responses relating to vertical aerial photographs (Combined map areas)



The graph illustrates that the 252 children taking part in the sample identified more paths, edges, areas and discrete features than any of the other organisational elements. The scores obtained within each of the seven organisational elements were then combined and t-tests for paired samples were carried out. Table 4.13 indicated that although children verbally identified more features on the vertical aerial photographs relating to Map Area A (mean score 4.95) than Map Area B (mean score

4.82), the results of the t-test showed that the difference was not statistically significant.

Table 4.13 Results of t-tests for paired samples relating to vertical aerial photographs

	Map area A (mean)	**Map Area B (mean)**	**t-value**	**d.f.**	**Sig.**
252 children	4.95	4.82	0.96	251	Ns
Year groups (36 chd)					
Reception	2.33	2.39	-0.24	35	Ns
Year 1	3.33	3.39	-0.21	35	NS
Year 2	4.14	4.31	-0.52	35	Ns
Year 3	4.61	5.28	-3.00	35	**
Year 4	6.22	5.78	1.50	35	Ns
Year 5	5.53	5.69	-0.59	35	Ns
Year 6	8.47	6.92	2.61	35	*

Key
** $p<0.01$
* $p<0.05$
Ns $p>0.05$

Although the results of the t-test for all children in the sample was not statistically significant, the pattern changed when considering the stratified samples of year groups (36 children in each year group). At Year group 3 children gave more verbal responses relating to Map area B (mean score 5.28) than for Map area A (mean score 4.61), whereas at Year group 6 children gave more verbal responses relating to Map area A (mean score 8.47) than for Map area B (mean score 6.92).

These results reflect the results of the 'large-scale Ordnance Survey map' variable when considering year groups. In both variables, the statistically significant differences were at Year groups 3 and 6. Comparing the number of responses with those given by children for the 'large-scale Ordnance Survey map' variable, more responses were given for the vertical aerial photograph variable. A t-test for a paired sample was carried out to consider if there were any differences between large-scale Ordnance Survey maps (mean score 2.52) and vertical aerial photographs (mean score 4.95) relating to Map area A. A further t-test was carried relating to Map area B showing a mean score of 2.37 for large-scale maps and a mean score of 4.82 for vertical aerial photographs. The results of the t-tests showed that for both map areas there were statistically significant differences at:

Map Area A $t = -21.095$; df 251; $p < 0.001$

Map Area B $t = -24.221$; df 251; $p < 0.001$

From these results, two observations were made, either children find it easier to interpret vertical aerial photographs than large-scale Ordnance Survey maps, or due to the iconic nature of vertical aerial photographs there is the opportunity to identify more cartographic features than on large-scale Ordnance Survey maps, which are depicted in plan form.

Gender differences were only apparent at Year group 2 when the mean scores of the boys (relating to both map areas) were significantly higher than the mean scores of the girls. The results of t-tests for independent samples indicated there were statistically significant gender differences at:

Map area A. (Year group 2). $t = -2.164$; df 17; $p < 0.05$

Map area B (Year group 2) $t = -2.069$; df 17; $p < 0.05$

The mean scores for Map area A were 3.67 (girls) and 4.61 (boys) and the mean scores for Map area B were 3.78 (girls) and 4.83 (boys). These results are inconsistent with Matthews' (1987) results indicating that boys identified more features on the vertical aerial photographs than the girls in each of the year groups and in both test areas.

Results of two factor analysis of variance (year groups x gender) relating to the vertical aerial photographs variable , one each for Map Area A, B and the combined map areas, indicated that there were no main effects for gender or for the gender x year groups interaction, but there were main effects for year groups:

Map Area A:

The results showed that there were no significant effects for gender ($F=1.527$, d.f.=1, $p>0.05$), or for the gender x year groups interaction ($F=1.313$, d.f. =6, $p>0.05$). There were significant main effects for year groups ($F=30.701$, d.f=6, $p<0.001$), and when considering adjacent year groups only, the results of the *post hoc* multiple comparisons Tukey HSD ($p<0.05$) tests showed statistically significant differences. The differences between adjacent year groups showing a developmental pattern were:

Year group 3 (mean score 4.61) and Year group 4 (mean score 6.22).

Year group 5 (mean score 5.33) and Year group 6 (mean score 8.47).

The developmental pattern between Year group 5 and Year group 6 is consistently occurring within the separate variables, the mean score of the older year group being significantly greater than the mean score of the younger year group. An interesting observation is, that although there is a significant difference between Year group 3 and Year group 4, and between Year group 5 and Year group 6, the difference between Year group 4 and Year group 5 is not statistically significant.

<u>For Map Area B</u>:

The results showed that there were no significant effects for gender ($F=1.715$, d.f.=1, $p>0.05$), or for the gender x year groups interaction ($F=1.117$, d.f. =6,$p>0.05$). There were significant main effects for year groups ($F=30.711$, d.f=6, $p<0.001$), and when considering adjacent year groups only, the results of the *post hoc* multiple comparisons Tukey HSD ($p<0.05$) tests showed statistically significant differences. The differences between adjacent year groups showing a developmental pattern were:

Year group 5 (mean 5.69) and Year group 6 (mean 6.92).

<u>For combined map areas</u>:

The results showed that there were no significant effects for gender ($F=0.259$, d.f.=1, $p>0.05$), or for the gender x year groups interaction ($F=0.853$, d.f. =6,$p>0.05$). There were significant main effects for year groups ($F=19.301$, d.f=6, $p<0.001$), and when considering adjacent year groups only, the results of the *post hoc* multiple comparisons Tukey HSD ($p<0.05$) tests showed statistically significant differences. The differences between adjacent year groups showing a developmental pattern were:

Reception year group (mean score 4.72) and Year group 1 (mean score 8.11).

Year group 5 (mean score 11.75) and Year group 6 (mean score 15.39).

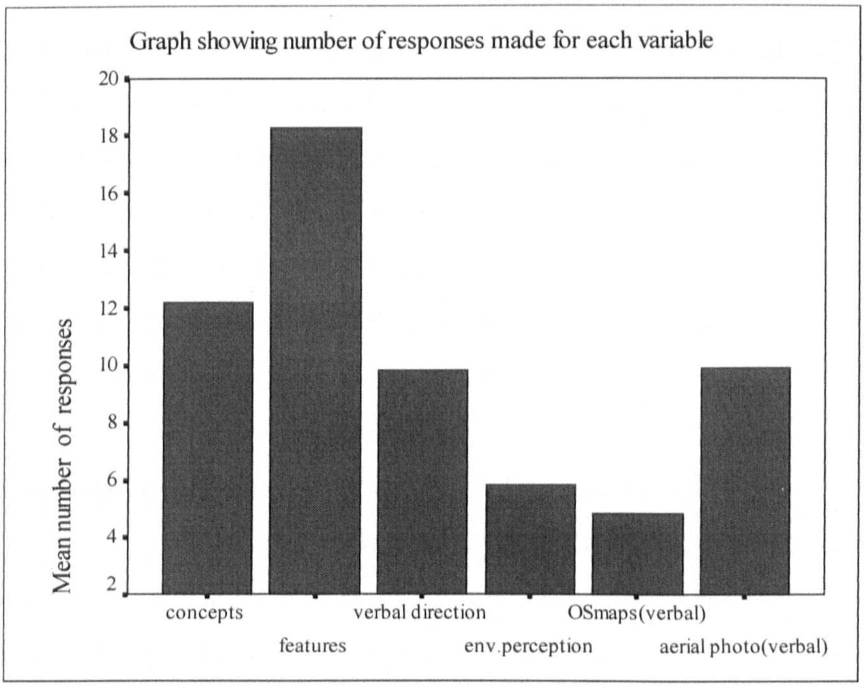
The results indicate that when combining the mean scores for both map areas, although the significant difference between Year groups 5 and 6 remains constant, the significant difference has changed from between the Year group 3 and 4 children (relating to Map area A) to between Reception year group and Year group 1 children when combining the mean scores for Map areas A and B. This again supports the notion that more than one familiar area should be tested (Matthews, 1984a). The results of the analysis of variance relating to the combined map areas are consistent with Stea and Blaut's (1973) results, in that six-year-old children (Year group 1) could identify features depicted on vertical aerial photographs. For example, the mean score for Year group 1 children was 8.11. The results for each of the three map areas show significant developmental patterns between Year group 5 and Year group 6. This result is not consistent with Blaut and Stea's (1971) results suggesting that they had strong support for the hypothesis that the ability to interpret aerial photographs was fully formed by the age of nine years. The present research indicates that age related development continues after the age of nine years.

OVERALL GENERAL MAPPING ABILITY VARIABLE

The results of the testing relating to the six separate variables producing quantitative measures highlighted the vast number of diverse outcomes. It was speculated that the reason for the diverse outcomes was because these variables contained other variables amounting to sixty-six in total. For example, the 'cartographic features' variable contained seven other variables (or organisational elements) of paths, nodes, landmarks, areas, edges, Ordnance Survey map features and discrete features; the 'verbal directional responses' variable contained five other variables of relevant language, directional language, full cardinal points, intermediate cardinal points and bearings. Yet it was important in the construction of the instrument that all aspects of 'general mapping' (as defined for the purpose of this research) were included. In the first instance, when collating the raw data, the variables within a particular variable were considered separately prior to the results being combined to form each of the six variables contained within the umbrella term of 'overall general mapping ability' producing quantitative results. It was important to compare these results with similar research as discussed in the literature review because when considering the 'overall general mapping ability' variable, to date there does not seem to have been an attempt to find a general measure and therefore no comparisons could be made with other research. Yet it is clear from the results of the separate variables outlined in the previous sections of this chapter that children do respond differently when presented with problems framed in different ways (Piaget 1971).

Prior to combining the number of responses for each variable, a graph (Figure 4.15) was constructed showing the number of responses (either drawn or verbal) made by the children taking part in the study for each of the separate variables including both map areas. The graph (Figure 4.15) illustrates the variations in the number of responses (either drawn or verbal) made by the children between each of the separate variables contained within the 'overall general mapping ability' variable. For example, more cartographic features were depicted on children's drawn cognitive map representations than cartographic concepts. Children made more verbal directional responses than environmental perception responses relating to features

Figure 4.15 Graph showing distribution of the separate variables



depicted on their drawn cognitive map representations. Approximately twice as many verbal responses relating to the 'vertical aerial photograph' variable were offered by the children than for the 'large-scale Ordnance Survey map' variable. As mentioned in the pilot study, the Ordnance Survey maps (1:12500) and coloured vertical aerial photographs (1:1000) were adjusted to ensure that they were approximately the same scale and identified the same geographical areas as the children's drawn cognitive map representations. By combining the raw scores for each of the separate variables the following rank order emerged:

cartographic features (mean score 18.37)
cartographic concepts (mean score 12.25),
interpretation of vertical aerial photographs (mean score 9.77)
verbal directional responses (mean score 9.44)
verbal environmental perception responses (mean score 5.88)
interpretation of large scale Ordnance Survey maps (mean score 4.89).

The total number of responses obtained within each of the separate variables were combined to form the 'overall general mapping' variable. T-tests for paired samples were carried out between Map Areas A and B in order to identify differences between the two different map areas, because children respond differently when presented with problems framed in different ways (Piaget 1971). Two factor analysis of variance tests (gender x year groups) relating to the 'overall general mapping ability' variable were carried out for Map area A, B and the combined map areas in order to determine if a developmental pattern or gender difference existed between the different year groups. As Liben (1997) argued, that as developmentalists, age is an important variable and we should be analyzing for group differences. Liben also argued, that given the long history of sex-related differences on spatial tasks, data should be routinely analysed by biological sex.

Year groups, gender and overall general mapping ability

Table 4.14 shows that there were significant differences for the sample as a whole and their overall general mapping responses (both drawn and verbal) between Map Area A and Map Area B. In order to see if these differences were statistically significant, a t-test was carried out and the results showed that the difference was significant at: $t = -4.340$; df 251: $p < 0.001$ relating to all children taking part in the study. The mean score relating to Map area B (31.42) being significantly greater than the mean score relating to Map area A (29.19). This difference was reflected at the Reception year group, Year groups 1, 3, and 5, the mean score being greater for Map area B than for Map area A. The results of the t-tests justifies the importance of testing more than one familiar map area as part of the instrument, in order to identify the 'overall general mapping ability' of primary school children. These results are consistent with Piaget's (1971) findings that children respond differently when presented with problems framed in different ways and Matthews' (1984a) findings that children encounter different but familiar large scale environments differently. Although t-tests relating to gender differences were carried out, the results indicated that there were no statistically significant differences between girls and boys for either Map Areas A or B, for either all children in the study, or individual year groups. This was supported by the results of the two-factor analysis of variance test (gender x year groups) relating to the 'overall general mapping ability' variable when considering the combined map areas. The results showed no significant main effects for either gender (F=0.781, d.f.=1,p>0.05) or the gender x year groups interaction (F=0.150, d.f.=6, p>0.05)

Table 4.14 Results of t-tests for paired samples relating to the overall general mapping ability variable and differences between Map Area A and Map Area B.

	Map Area A (mean)	**Map Area B (mean)**	**t-value**	**d.f.**	**Significance**
252 children	29.19	31.42	-4.34	251	***
Year groups (36 children)					
Reception	13.22	16.08	-4.68	35	***
Year 1	19.94	22.56	-3.18	35	**
Year 2	25.89	26.42	-0.36	35	Ns
Year 3	28.03	32.78	-3.35	35	**
Year 4	35.58	34.28	1.11	35	Ns
Year 5	34.67	38.19	-2.24	35	*
Year 6	46.97	49.67	-1.44	35	Ns

Key
*** p< 0.001
** p<0.01
* p<0.05
Ns p>0.05

One of the questions asked in the present research was "Are there gender differences in primary school children's overall general mapping ability?" The result of the present research does not support the proposition that either girls or boys are superior in their overall general mapping ability. Matthews (1984c) suggested that boys were superior to girls, and Wickstead (1991) suggested that girls were superior to boys. However both of these results were only concerned with some, but not all, of the variables contained within the umbrella term of 'overall general mapping' and therefore it is difficult to make comparisons.

The results of two factor analysis of variance tests (year groups x gender), relating to the 'overall general mapping ' variable, one each for Map area A, B and the combined map areas indicated that there were significant main effects for year groups for each of the three map areas, but no main effects for gender or gender x year group interaction. The results are as follows:

For Map Area A:

Relating to Map area A, the results showed no significant effects for gender ($F=0.457$, d.f.=1, $p>0.05$). or for gender x year group interaction ($F=0.136$, d.f.= 6, $p>0.05$). There were significant main effects for year groups ($F=59.127$, d.f.=6, $p<0.001$, and when considering adjacent year groups only, in order to determine if a developmental pattern existed, the *post hoc* multiple comparisons (Tukey HSD :$p<0.05$) showed that the differences were between:

Reception year group (mean score 13.22) and Year group 1 (mean score 19.94)
Year group 3 (mean score 28.03) and Year group 4(mean score 35.58)
Year group 5 (mean score 34.67) and Year group 6 (mean score 46.97)

These results indicate a significant developmental pattern between the Reception and Year group 1: between Year groups 3 and 4 and between Year groups 5 and 6, the mean scores for each of the three older year groups being significantly greater than the mean scores for the three younger year groups.

For Map Area B:

Relating to Map B, the results showed no significant effects for gender ($F=0.696$, d.f.=1, $p>0.05$), or for gender x year group interaction ($F=0.210$, d.f.=6, $p>0.05$). There were significant main effects for year groups ($F=68.144$, d.f.=6, $p<0.001$, In order to determine if a developmental pattern existed, by considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD :$p<0.05$) showed that there were significant differences were between:

Reception year group (mean score 16.08) and Year group 1 (mean score 22.56)
Year group 2 (mean score 26.42) and Year group 3 (mean score 32.78)
Year group 5 (mean score 38.19) and Year group 6 (mean score 49.67)

These results are identical to the results for Map area A relating to the extreme year groups of the Reception, Year groups 1, 5 and 6 showing a significant developmental pattern. However, instead of the difference being between Year groups 3 and 4 (as for Map area A), the significant development pattern for Map area B is shown between Year groups 2 and 3.

Combined map areas:

Relating to the combined map areas, the results showed no significant effects for gender (F=0.781, d.f.=1,p>0.05), or for the gender x year group interaction (F=0.150, d.f.=6, p>0.05). There were significant main effects for year groups (F=81.269, d.f.=6, p<0.001, and when, attempting to determine if a developmental pattern existed, by considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD, p<0.05) showed that the significant differences were between:

Reception year group (mean score 29.30) and Year group 1 (mean score 42.00)

Year group 1 (mean score 42.00) and Year group 2 (mean score 52.31)

Year group 5 (mean score 72.86) and Year group 6 (mean score 96.92)

The results relating to the combined map areas are identical to the results of both Map areas A and B, when considering the extreme year groups of the Reception, Year groups 1, 5 and 6 showing a significant developmental pattern. However, the significant difference between the 'middle year groups' changed from being between Year groups 3 and 4 (Map area A) to being between Year groups 2 and 3 (Map area B). Yet, when considering the combined map areas, the significant difference is indicated as being between Year groups 1 and 2.

The above results indicate that there is a significant developmental pattern between some, but not all year groups. Between the extreme year groups of Reception and Year group 1: and between Year groups 5 and 6, the significant differences remain constant, but this differs within the 'middle year groups', depending on the map area being tested. An interesting observation indicates that there are no significant differences between Year groups 4 and 5 for any of the three map areas being tested. The results again justify the importance of testing more than one familiar area as part of the instrument in order to identify the overall general mapping ability of primary school children.

As previously discussed, it was speculated that the 'stages of development' variable, producing a qualitative measure, although inter-related, was not compatible with the other variables producing a quantitative measure. However, as Table 4.15 indicates the 'stages of development' variable is compatible with the 'overall general mapping' variable producing a quantitative measure. The table outlines the distribution of the mean number of responses relating to the 'overall general mapping ability' variable (combined map areas) producing a quantitative measure into stages of development or developmental categories relating to the combined map areas. What has emerged is the wide range of year groups within each stage of development or developmental categories.

Table 4.15 showing mean number of responses made by children at different stages of development (developmental categories).

Developmental categories	Stage of Development	Year group (range)	No. children	(Mean score)	score (range)
Category 1	Emergent	Reception – Year 5	17	26.59	11 - 52
Category 2	Topological	Reception – Year 2	3	30.67	18 - 46
Category 3	Projective 1	Reception – Year 6	127	49.24	24 - 86
Category 4	Projective 1 / 2	Year 1 – Year 6	41	62.36	41 - 83
Category 5	Projective 2	Year 2 – Year 6	33	85.06	62 - 110
Category 6	Projective 1/2/Euc.	Year 5 – Year 6	4	78.25	71 - 85
Category 7	Projective 2/Euc	Year 3 – Year 6	20	100.80	63 - 148
Category 8	Euclidean	Year 5 – Year 6	7	114.00	92 - 148

Table 4.15 shows that 17 children (7%) from the reception through to the Year group 5 children were placed at the emergent stage of development or (developmental category 1). However, by placing children's drawn cognitive map representations into an emergent stage of development does not imply that children at this stage do not possess any general mapping ability, it simply means that they have not yet reached the topological stage of development. They were unable to follow the researcher's instructions by depicting particular features on their drawn cognitive map representations and by drawing the start of a route at one of these features mentioned in the instructions. At the same time these children do possess general

mapping ability that can be elicited through other general mapping variables producing a quantitative score. For example, the overall mean score was approximately 27 and included:
cartographic features (mean score 9.24),
verbal directional responses (mean score 5.98),
vertical aerial photographs (mean score 5.94)
verbal environmental perception responses (mean score 3.71),
large scale Ordnance Survey maps (mean score 2.41).
These results justify the criterion that an emergent stage should be included in the checklist relating to the 'stages of development' variable.

Only three children (approximately 1%) ranging from reception through to Year group 2 children were placed at the topological stage of development or developmental category 2. The mean overall score was approximately 31 and this score is very similar to the 'emergent' children's overall mean score. Children were placed at this stage because they had the ability to follow the researcher instructions and depict particular features on their drawn cognitive map representations and show a route starting at the feature mentioned in the instructions. The cartographic concept of 'route 1' is the only concept contained within the topological stage of development.

At the projective one stage or developmental category 3, the mean overall score was approximately 49 and 127 children (approximately 50%), ranging from the reception through to the Year group 6 children. For example, 23 reception year children and two Year group 6 children were placed at this stage. The majority of children's drawn cognitive map representations were placed at this stage. Children at this stage are learning to decentre themselves or think in abstract (Donaldson 1978) and they can begin to imagine a route in their minds from different viewpoints and recreate their images onto paper as a map. This is the main and most important difference between projective space and the topological relationships.

At the over-lapping projective one/two stage or developmental category 4, the mean overall score was approximately 62 and 41 children from Year group 2 through to

Year group 6 children were placed at this stage. Children were placed at this stage because although they could not show an understanding of all cartographic concepts contained within the projective one stage of development (Figure 3.10), they were able to show an understanding of some of the cartographic concepts contained within the projective two stage of development.

Thirty-three children (approximately 13%) ranging fromYear group 2 through to the Year group 6 were placed at the projective 2 stage of development (developmental category 5), and their mean overall score was approximately 85. At the over-lapping projective one/two/Euclidean stage or developmental category 6, the mean overall score of 78 was less than the mean score produced by the projective two stage children. An interesting observation was highlighted in that only four of the 252 children taking part in the testing were placed at this stage. The four children (from Year groups 5 and 6) were unable to show an understanding of either the concept of labelling or detail (1) at the projective 1 stage of development (Figure 3.10) on their drawn cognitive map representations. However, they were able to show an understanding of the concept of perspective (2) at the Euclidean stage of development or developmental category 8. These results are consistent with Piaget's arguments that in addition to each stage being necessary for the following one, some of the concepts contained within the stages of projective and Euclidean space develop in parallel and are mutually interdependent (Gerber 1981, Ottosson 1987).

At the over-lapping projective two/ Euclidean stage or developmental category 7, the mean overall score was approximately 101 and 38 children (from Year group 3 through to Year group 6) were placed at this stage. Finally, seven children from Year groups 5 and 6 were placed at the Euclidean stage of development or developmental category 8 and their mean overall score was 114.

Table 4.16 shows the mean number of combined responses placed into year groups and again a developmental pattern emerges. For example, the greater the age (year groups) the greater the mean score. But what is difficult is to correlate the stages of development (developmental categories) with year groups. However, considering the extremes the mean score at the developmental category 1 was 26.59 and at the reception year group the mean score was 29.13. At the developmental category 8 the mean score was 114.00 and at Year group 6 the mean score was 96.92.

Table 4.16 showing mean number of 'overall general mapping' responses made by children at different year groups (combined map areas)

	Overall mean score	**Range of scores**
252 children	60.58	11 – 148
Year groups (36 children)		
Reception	29.31	11 – 48
Year 1	42.00	27 – 63
Year 2	52.31	29 – 98
Year 3	60.81	29 – 103
Year 4	69.83	41 – 111
Year 5	72.86	46 – 110
Year 6	96.92	63 – 148

The data displayed on Table 4.15 relating to stages of development or developmental categories and Table 4.16 relating to year groups were examined by means of a two factor analysis of variance (stages of development x year groups) relating to the 'overall general mapping ability' variable. Although the results showed no significant effects for the stages of development x year groups interaction (F=0.899, d.f.=21, p>0.05, there were significant main effects for stages of development (F=20.178, d.f=7, p<0.001, and for year groups (F=10.339, d.f.=6, p<0.001).In order to determine if a developmental pattern existed, by considering adjacent developmental categories (stages of development) or year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD :p<0.05) showed that there were significant differences were between:

For developmental categories (stages of development)

Projective 1 (mean 49.24) and over-lapping projective 1 / 2 stages (mean 62.15)
Over-lapping projective 1 / 2 (mean 62.15) and projective 2 stages (mean 84.64)
Over-lapping projective 1 / 2 /Euclidean (mean 78.25) and over-lapping projective 2 /Euclidean (mean 100.8)

Although the results on Table 4.15 indicate that the more advanced the developmental category or stage, the greater the mean score (apart from the over-lapping projective 1 / 2 / Euclidean stage of development or developmental category 6), what is interesting is that the significant differences only occur when an 'over-lapping stage of development' is present. But this does not occur at every 'over-lapping stage of development'. For example, the differences between the projective two and over-lapping projective 1 /2 / Euclidean stages: and between the over-lapping projective 1 / 2 / Euclidean and Euclidean stages of development are not statistically significant.

<u>For year groups</u>

The mean scores on Table 4.16 relating to the 'overall general mapping ability' variable indicate an age related development. For example, the greater the age (year group) the greater the mean score. The results of the two factor analysis of variance (stages of development x year groups) relating to the 'overall general mapping ability' variable showed that main significant effects for 'year groups' ($F=10.339$, $d.f.=6$, $p<0.001$).In order to determine if a developmental pattern existed, by considering adjacent year groups only, the results of the *post hoc* multiple comparisons (Tukey HSD :$p<0.05$) showed that there were significant differences were between:

Reception (mean score 29.31) and Year group 1 (mean score 42.00)
Year group 1 (mean score 42.00) and Year group 2 (mean score 52.31)
Year group 2 (mean score 52.31) and Year group 3 (mean score 60.81)
Year group 3 (mean score 60.81) and Year group 4 (mean score 69.83)
Year group 5 (mean score 72.86) and Year group 6 (mean score 96.92)

These results indicate that there is a statistically significant development pattern between year groups and primary school children's overall general mapping ability apart from between Year group 4 and Year group 5. Although the mean score for Year group 5 was greater than for Year group 4 the difference was not significant.

The results of the two factor analysis of variance (stages of development x year groups) relating to the 'overall general mapping ability' variable shows that there are no significant effects for the stages of development x year groups interaction ((F=0.899, d.f.=21, p>0.05) Although there are main effects between some of the 'stages of development' and 'overall mapping ability' scores, and between most of the 'year groups' and 'overall mapping ability' scores, in reality it is difficult to match stages of development with year groups because the majority of the children were placed at the projective one stage of development. It can be speculated from the results that cognitive map representations (both drawn and verbal) can be used as a measure of primary school children's overall general mapping ability. There are two ways of measuring, both producing a quantitative score and both indicating a developmental pattern, one is age (or year group) related and the other is stage (or category) related. However, although stages and ages are inter-related they are not statistically compatible, even though the mean scores for both variables are similar.

The following and concluding chapter is concerned with drawing together the findings of the research and to determine if the research questions were answered. The research questions were "Can a method be developed to measure children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" In addition, "Should an emergent stage be included to accommodate children who could not be placed into a stage of development. Finally, because there is still speculation concerning gender, the question "Are there gender differences overall general mapping ability?" was also considered.

CHAPTER FIVE

THE CONCLUSION

This chapter is concerned with drawing together the findings of the research and to determine if the research questions were answered. The research questions were "Can a method be developed to measure children's overall general mapping ability?" If so, "Can it be used across the primary age range with a wide variety of pupils at different stages of development?" In addition, "Should an emergent stage be included to accommodate children who could not be placed into a stage of development. Finally, because there is still speculation concerning gender, the question, "Are there gender differences in overall general mapping ability?" was also considered.

This research (working within a Piagetian paradigm) examined the possibility of using primary school children's cognitive map representations (drawn and verbal), relating to two different large-scale familiar areas as a means of measuring their overall general mapping ability. Separate variables relating to drawn cognitive map representations (Catling 1978), verbal directional (Blades and Medlicott 1992), environmental perception (Hart 1979) responses and verbal interpretation of large scale Ordnance Survey maps and vertical aerial photographs (Matthews 1989) have been identified for their assessment by other researchers. However, to date there does not seem to have been an attempt to find a general measure of primary school children's overall general mapping ability by combining the results of the different variables and from two different large scale familiar areas. It is clear that children respond differently when presented with problems framed in different ways (Piaget 1971, Matthews 1984a) and consequently it cannot be assumed that a measure on any one variable can be extrapolated to form a measure of overall general mapping ability. This research attempts to use primary school children's cognitive map representations (drawn and verbal) of two different but familiar large-scale environments as a means of measuring their overall general mapping ability. One of the aims was to construct an instrument that could be used by teachers in their classrooms as a standardised test that would produce reliable and generalisable judgements of primary school children's overall general mapping ability.

For the purpose of this research the definition for the umbrella term of 'overall general mapping ability', embraces the following variables:
developmental stages of drawn cognitive map representation
cartographic concepts depicted on cognitive map representations
cartographic features depicted on cognitive map representations
verbal directional responses
verbal environmental perception responses
verbal interpretation of large scale Ordnance Survey maps
verbal interpretation of vertical aerial photographs

The results relating to the 'stage of development' variable showed that the spread of stages was more complex than either Piaget's (1955; 1960) three stages or Catling's (1978) four stages of development. Although eight different stages of development (developmental categories) emerged, the majority of children's drawn cognitive map representations were placed at the projective one stage of development (developmental category 3). The checklist used to place children's drawn cognitive map representations into 'stages of development' served two purposes. It also identified the possible understanding of twenty-seven separate cartographic concepts producing a quantitative score. These concepts formed the 'cartographic concepts' variable and the results of the testing indicated all children (252) taking part in the sample depicted more cartographic concepts on their drawn cognitive map representations for Map area B than for Map area A. The differences were statistically significant for all children and all year groups (36 children per year group), apart from Year group 2. A developmental pattern between adjacent year groups also emerged, but the results showed that differences were only significant between Year groups 5 and 6.

In contrast to the 'cartographic concepts' variable, the results relating to the 'cartographic features' variable showed that more features were depicted on children's drawn cognitive map representations for Map area A than for Map area B.

Again, a developmental pattern emerged, the mean scores for Year group 5 for both map areas being significantly lower than mean scores for Year group 6. Although the results relating to gender were not statistically significant when considering Map areas A and B separately, by combining the mean scores, the results showed statistically significant differences between Year group 5 boys and Year group 6 girls. The results relating to gender are inconsistent with Matthews' (1984c) results suggesting boys' maps were consistently better than girls' maps showing more detail and O'Laughlin and Brubaker's (1998) results indicating that there were no apparent gender differences.

Children offered more 'verbal directional responses' for Map area B than Map area A, and these results were statistically significant for all children and all year groups apart from the reception year group. Relating to Map area B, the results showed a significant main effect between Year group 5 boys and Year group 6 girls. These results are similar to the results relating to the 'cartographic features' variable. In both variables, the Year group 6 girls' mean score was significantly greater than Year group 5 boys' mean score. The results relating to gender differences are consistent with Blades and Medlicott's research (1992) in that there was no evidence that the male subjects performed better than the female subjects.

The 'verbal environmental perception' variable was included within the umbrella term of 'general mapping ability' because when constructing drawn cognitive map representations of familiar areas, we think about certain features in both a cognitive and affective way. We not only think about what is there, but also, how we feel about these places (Siegel 1982, Golledge 1999). Although the results showed that although there were differences between extreme and random year groups, there were no significant differences between adjacent year groups, indicating that there was no evidence of a developmental stage for this particular variable. There were no main effects for gender and these results are inconsistent with Hart's (1979) findings, which showed that when considering all children, boys gave more responses than the girls.

Sections of large-scale Ordnance Survey maps depicting the same familiar areas as the children's drawn cognitive map representations were used by the children. Although they verbally identified more features on the large-scale Ordnance Survey map relating to Map Area A than Map Area B, the results were not statistically significant. However, the pattern changed when considering year groups. The Year group 3 children offered more verbal responses relating to Map area B and the Year group 6 children offered more verbal responses relating to Map area A. There was a significant main effect for gender relating to Map area A between Year group 5 girls who identified less cartographic features than the Year group 6 boys. This result is consistent with Matthews (1987) suggesting that boys identified more than girls. Relating to a developmental pattern, the significant main effects for Map area A were between Year group 5 and Year group 6. When considering Map area B, four out of the seven year groups showed significant differences. The differences were between Year group 2 and Year group 3; and between Year group 5 and Year group 6. When considering the combined map areas, the significant differences were between Year group 3 and Year group 4; and between Year group 5 and Year group 6. The results indicate that when combining the mean scores for both map areas, although the significant difference between Year groups 5 and 6 remains constant, the significant difference has changed to being between Year group 3 and 4. A tentative reason is that it is probably to do with children thinking in different ways in different contexts, again supporting the notion that more than one familiar area should be used (Piaget 1971, Matthews 1984a).

The vertical aerial photographs were approximately the same scale as the large-scale Ordnance Survey maps and the photographs and maps were of the same familiar areas as the children's drawn cognitive map representations. Although children verbally identified more features on the vertical aerial photographs relating to Map Area A than Map Area B, the difference was not statistically significant. However, the pattern changed when considering year groups. The Year group 3 children gave more verbal responses for Map area B and the Year group 6 children gave more verbal responses for Map area A. Gender differences were only apparent at Year group 2 when the mean scores for the boys (relating to both map areas) were significantly higher than the mean scores for the girls. Yet when combining the mean scores for both map areas, the results showed there were no main effects for gender. Significant differences between adjacent year groups indicating a developmental pattern for Map area A were between Year group 3 and Year group 4.; and between Year group 5 and Year group 6. For Map area B the difference was between Year group 5 and Year group 6. When combining the mean scores for both map areas, although the significant difference was between Year groups 5 and Year group 6 remains constant, the significant difference changed to being between the Reception and Year group 1 children. These results are consistent with Stea and Blaut's (1973) results, in that six-year-old children (Year group 1) could identify features depicted on vertical aerial photographs. Yet the results showing significant developmental patterns between Year group 5 and Year group 6. is not consistent with Blaut and Stea's (1971) results suggesting that the ability to interpret aerial photographs was fully formed by the age of nine years. The present research indicates that age related development continues after the age of nine years.

Approximately twice as many responses were given for the 'vertical aerial photograph' variable than for the 'large-scale Ordnance Survey map' variable and two observations were made. Either children find it easier to interpret vertical aerial photographs than large-scale Ordnance Survey maps, or due to the iconic nature of vertical aerial photographs there is the opportunity to identify more cartographic features than on large-scale Ordnance Survey maps, which are depicted in plan form.

The results relating to the six separate variables highlighted a vast number of diverse outcomes. Yet it was important in the construction of the instrument that all aspects of 'general mapping' were included. The mean scores for each of the separate variables were combined in order to identify the 'overall general mapping' variable. The results of the testing relating to Map area A show a statistically significant developmental pattern between the Reception and Year group 1; between Year group 3 and Year group 4; and between Year group 5 and Year group 6. These results are similar to the results for Map area B relating to the extreme year groups between the Reception year group and Year group 1; and between Year group 5 and Year group 6. However, instead of the difference being between Year groups 3 and 4, the significant development pattern is shown between Year group 2 and Year group 3.

The combined map areas reflect the results of Map areas A and B, when considering the extreme year groups of the Reception year group and Year group 1 and between Year group 5 and Year group 6, but the significant difference is now indicated as being between Year group 1 and Year group 2. Overall, the results indicate a developmental pattern between some, but not all year groups. Between the extreme year groups of Reception and Year group 1: and between Year groups 5 and 6, the significant differences remain constant, but this differs within the 'middle year groups', depending on the map area being tested. An interesting observation indicates that there are no significant differences between Year groups 4 and 5. The results of the testing also showed significant main effects between some of the 'stages of development' and the 'overall general mapping ability' mean scores. However, it is difficult to match the eight stages of development (developmental categories) with the seven year groups (36 children per year group) because the majority of the children were placed at the projective one stage of development (developmental category 3). Although 'stages' and 'ages' are inter-related they are not statistically compatible.

The present research has answered the main questions and shown that it was possible to develop a method to measure children's 'overall general mapping ability', which could be used across the primary age range with a variety of pupils at different stages of development. Yet this is an area greatly in need of research, as explicit and objective techniques of monitoring the interpretation of cognitive map representations are required. Wickstead's (1991) research raised questions concerning the subjectivity of attempting to use Catling's (1978) illustrated table for interpreting children's drawn cognitive map representations into stages of development. Yet the present research has shown that by changing Catling's comments into questions producing 'Yes/No' answers, and by using the definitions of general mapping terms by (Catling, 1978 & 1981; Bale, 1987; Mills et al, 1988; Harrison and Harrison, 1989; Boardman, 1990; Weigand, 1993; Marsden and Hughes, 1994), the subjectivity could be removed. Even so, the results relating to the 'stages of development' variable showed that although the majority of children (ranging from the Reception year to the Year group 6) were placed at the projective one stage of development, the spread of stages was more complex than either

Piaget's (1955; 1960) three stages or Catling's (1978) four stages of development. The problem of 'over-lapping' of stages produced eight different stages of development (or developmental categories). For example, forty-one children (ranging from Year group 1 to Year group 6) were placed at the 'over-lapping' projective 1 / 2 stage of development (or developmental category 4). They were placed at this stage because although they were unable to depict an understanding (on their drawn cognitive map representations) of all the cartographic concepts contained within the projective 1 stage, they could identify some of the concepts contained within the projective 2 stage of development. Four children (ranging from Year group 5 to Year group 6) were placed at the 'over-lapping' projective 1/2/Euclidean stage (or developmental category 6) because although they could not identify all of the concepts contained within the projective 1 stage of development (or developmental category 3), they could depict an understanding of some of the concepts from both the projective 2 and Euclidean stages of development. Twenty children (ranging from Year group 3 to Year group 6) were placed at the 'over-lapping' projective 2/Euclidean stage of development (or developmental category 7) because they identified all cartographic concepts contained within the projective 1 stage of development and some of the cartographic concepts from both the projective 2 and Euclidean stages of development.

In addition to the complexities of 'over-lapping', an 'emergent' stage of development was also included as the result of the testing showed that 7% of the sample was placed at this stage. Children were placed at this stage because they were unable to follow the researcher's instructions and depict an understanding of the concept of 'route' on their drawn cognitive map representations. Had they done so, they would have been placed at the topological stage of development. However, they did have the ability to respond in the other variables contained within the umbrella term of 'overall general mapping ability'. For example, they attained the following mean scores for: cartographic features (9.24), direction (5.98), vertical aerial photographs (5.94) environmental perception (3.71), large-scale Ordnance Survey maps (2.41). These results indicate that an 'emergent stage' be included in the instrument in order to accommodate children who could not be placed into one of Catling's (1978) four stages of development.

A further issue was concerned with nearly half of the children producing drawn cognitive map representations, which were assigned different stages of development between Map Areas A and B. The problem for the researcher was whether to challenge or acknowledge the Piagetian perspective. Because of the Piagetian perspective that children progress from stage to stage a decision was taken to use the higher stage of development achieved by the children. This was a straight forward task when considering children who were placed at a definite stage of development, but when considering children who were placed at an 'over-lapping' stage, ten children were actually moved up one stage of development as a result of using the combination of the two map areas.

The results of the testing indicated that there is a statistically significant developmental pattern between year groups and the 'overall general mapping ability' mean score apart from between Year groups 4 and 5. Although the mean score for Year group 5 was greater than for Year group 4 the difference was not significant. There was also a developmental pattern between stages of development and the 'overall general mapping ability' mean score. For example, the more advanced the stage of development (or developmental category) the greater the mean score, apart from the over-lapping projective 1 / 2 / Euclidean stage of development (or developmental category 6). What is interesting is that the main effects only occur when an 'over-lapping stage of development' is present, but this does not occur at every 'over-lapping stage of development'. For example, the differences between the projective two and over-lapping projective 1 /2 / Euclidean stages: and between the over-lapping projective 1 / 2 / Euclidean and Euclidean stages of development are not statistically significant.

Although there are main effects between some of the 'stages of development' and the 'overall general mapping ability' scores, and between most of the 'year groups' and 'overall general mapping ability' scores, in reality it is difficult to match the eight stages of development (developmental categories) with the seven year groups (36 children per year group) because the majority of the children were placed at the projective one stage of development (developmental category 3), yet there are similarities. For example, the mean score obtained by children at the emergent stage was 26.59 and at the reception year group the mean score was 29.13. The children placed at the Euclidean stage obtained a mean score of 114.00 and at Year group 6 the mean score was 96.92. However, although there was a developmental pattern between the mean score and stages of development or categories of development, and also, between year groups and mean scores, there were no main effects between the 'year groups' x 'stages of development' interaction relating to the 'overall general mapping ability' variable. Although 'stages' and 'ages' are inter-related they are not statistically compatible, even though the mean scores for both variables are similar. This simply means that there are two ways of measuring primary school children's 'overall general mapping ability', both producing a quantitative score and both indicating a developmental pattern, one is age (or year group) related and the other is stage (or category) related. It can be speculated from the results that cognitive map representations (both drawn and verbal) can be used as a measure of primary school children's overall general mapping ability.

The final question "Are there gender differences overall general mapping ability?" was also considered in the present research and although there is still speculation concerning gender, these results showed that there were no statistically significant gender differences.

The present research has answered the main questions and shown that it was possible to develop a method to measure children's 'overall general mapping ability', which could be used across the primary age range with a variety of pupils at different stages of development. However, the procedure used was time-consuming and impractical to be used by classroom teachers. A possible solution would be to select a number of predictors and construct a simple and reliable checklist. By analysing the results of the testing it was found that it was possible to modify and use the checklist relating to the stages of development variable as a surrogate measure of children's general mapping ability. From the results of Spearman's correlation coefficient tests carried out between the stages of development variable and the twenty-seven cartographic concepts, it was possible to select fifteen predictors. However, using a surrogate measure was abandoned because it would only relate to one variable and not produce a realistic and fair assessment of children's overall general mapping ability.

The construction of two drawn cognitive map representations relating to two different map areas, although an important part of the instrument proved too time-consuming. Implications for future research could be the replication this instrument, but instructions to the children should be altered in a way to include the two different map areas but only requiring the construction of one drawn cognitive map representation. For example, instead of using the Mickey Mouse story, the new story could involve the coach driver arriving at the school and looking for the head-teacher. The children would be asked to draw a map (on A3 sized paper) for the coach-driver, by starting at the main school gate, following the pavement, through a different gate and into the playground (this part of the map would relate to Map area A). The children would continue constructing their drawn cognitive map representation in order to show the coach driver back to the coach and then they follow the instructions relating to the other familiar area (Map area B), such as the route to the swimming pool, McDonald's or shopping precinct. By adopting this procedure it is speculated that the time spent on testing could be reduced by approximately 50%, as only one checklist for each of the variables would be required and this would make future research more manageable. By following the same procedure as discussed in the methodology, but combining the two different map areas onto the one drawn cognitive map representations, it is hypothesised that the results of any future testing would be consistent with the results of this present research relating to the overall general mapping ability variable.

The present research has established a reliable and generalisable method, which used children's cognitive map representations (drawn and verbal) as a means of measuring their overall general mapping ability. Although a somewhat lengthy procedure, it can by used by primary school teachers in their classrooms, as a standardised test, to assess children's overall general mapping ability at different stages and ages of development across the primary range. Equally important, it has used both 'good geographical practice' of starting with what is on ones own doorstep and children's personal cognitive map representations as implicit parts of the instrument.

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