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**The Efficacy of Using a Three Dimensional,
Interactive Model to Teach Environmental Concepts
to Children with a Visual Impairment**

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fulfilment of the requirements for
the Degree of Master of Philosophy
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Abstract

Previous research has identified that children with a visual impairment have difficulty in acquiring independent travel skills. In the past, the research has been concentrated on body and spatial concepts with a more recent emphasis on spatial representation and the use of tactile maps. However, very little attention has been paid to three dimensional models or the teaching of environmental concepts. Consequently, a study was undertaken to see if the use of a three dimensional interactive model was efficient at teaching environmental concepts to four visually impaired children. The study utilised a changing criterion design with an environmental probe to assess the outcome. It was found that the children learnt the concepts taught and were able to transfer knowledge gained on the model to the real environment. In line with other research findings, two children, the youngest and the one with the greatest degree of vision impairment, were found to be unable to plan and execute routes in the real environment. This may be explained by their lack of understanding of Euclidean concepts. The model was also found to have a number of significant advantages over tactile maps as a tool for introducing environmental concepts. Some areas for further investigation are identified.

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The Efficacy of Using a Three Dimensional, Interactive Model to Teach Environmental Concepts to Children with a Visual Impairment

Children with a visual impairment have difficulty in acquiring independent travel skills (Lowenfeld, 1981). Educational assistance is necessary to help in acquisition of these skills and is usually provided through an orientation and mobility programme (O & M) (LaGrow, in press). "O & M is the term which refers to both the techniques and strategies required for independent travel by blind and visually impaired people and the success based sequence of instruction used to promote independent travel among this population" (LaGrow & Weessies, 1994, p195).

Orientation refers to the ability to understand one's position in space, while mobility is the act of moving safely and efficiently through space (Hill & Ponder, 1976). A full range of body and spatial concepts is required to ensure that movement is possible, safe and efficient. Spatial and environmental concepts are required to allow the person to understand their position in space (Long & Hill, 1997).

Concept and Concept Development

A concept is, broadly speaking, a mental representation of an object or an idea of how something is. These are either concrete or abstract, relating either to objects such as road or footpath or abstractions such as give-way or traffic flows respectively (Hill & Blasch, 1987). The ability to understand a concept relates directly to the level of cognitive development. In order to teach concepts in a meaningful way it is therefore necessary to have an understanding of cognitive development (Potter, 1995).

Piaget, theorises that all children progress through various stages in their cognitive development in roughly the same way and order. There are four main stages of development (a) sensori motor (0-2years of age), (b) pre operational (2-7 years of age), (c) concrete operational (7-11 years of age) and, (d) formal operational (11+ years of age). The age at which these levels are achieved is affected by a number of different factors including inherited capabilities and experience (Wadsworth, 1971).

As children progress through these stages they go from being egocentric to being able to perceive things from different perspectives. They gain the ability to sequence and order things in a logical and structured way. They begin to be able to reverse operations and judge size, space, causality and time/distance relationships. They begin to understand the concept of rules, and move from having no logical thought to being able to solve real as well as theoretical problems (Wadsworth, 1971).

Perception through the integration of sensory information and experience of the environment is also essential to concept acquisition (Gibson, 1967). One of the main prerequisites to any concept is the ability to be able to perceive differences and similarities between objects and ideas so that the items can be categorised and concepts developed. Children are, however, only ready to learn a new concept when they have in place the prerequisites necessary for understanding that concept (Wadsworth, 1971). Therefore, concepts also need to be introduced in a structured and ordered manner by means of a hierarchy (Potter, 1995; Wadsworth, 1971).

Concepts are generally formed in two stages, abstraction and generalisation. It is at the abstraction stage that perception of similarities and differences occur and labels are given to the concepts. This stage could be further broken down into a concrete knowledge of the concepts and then developed into a functional understanding of the

concept (Zweibelson & Barg, 1981). The concept then needs to be generalised. It is this process where the knowledge of the similarities and differences is applied (Gibson, 1967).

Children with a visual impairment generally experience delays in concept development. They, in fact, can lag behind their sighted peers by as much as four to eight years in their concept development, often verbalising concepts with no true understanding (Hill & Blasch, 1987). The degree of this lag is related to both age of onset and the degree of visual disability associated with the impairment (La Grow, in press).

Vision is the primary source for building the richness of understanding about our environment. This information is gathered through a variety of sources (ie. books, television, CD Roms, movies etc), in addition to direct experience with the environment (La Grow, in press). The visually impaired child's access to these additional sources of information is limited, as is their access to more direct environmental experiences. Therefore it is necessary to specifically teach many of the concepts that sighted children pick up incidentally.

The main concepts required for O & M can be broadly divided into three main areas; (a) body, (b) spatial and (c) environmental concepts. Body concepts include, body parts, body schema and body planes (Hill & Blasch, 1987). Good body concepts are essential as the child progresses since they use these concepts to build points of reference. They tend to use body centred reference cues in preference to external ones, since these tend to be consistent and reliable (Millar, 1995). These points of reference prove to be important as the child develops the concepts of self to object relations and later object to object relationships.

As the child grasps a better understanding of his/her body parts, functions, relationships and co-ordination it can lead on to the development of spatial and environmental concepts. Spatial concepts cover a broad category which includes directional, positional, object to self and object to object concepts, action concepts, concepts of time, space, distance and speed as well as concepts of shape and form (Hill & Blasch, 1987). Environmental concepts relate more to objects in the environment, such as footpaths, signs and roads, and their functions and layout within the large scale environment (LaGrow, in press).

The final stage is perhaps when children have developed Euclidean concepts allowing them to organise spatial information in a "survey" or overall view of an area. Euclidean concepts allow children to plan detours and plan unfamiliar routes and to generalise environmental information which will enable them to become independent travellers (Potter, 1995).

Spatial Representation

Vision is our primary source of stimulation and integration of sensory information especially for organising spatial relations (Hill & Blasch 1987). The other sensory channels are not as efficient at gathering or assimilating this information. Furthermore they often require movement to gain this information.

Large scale concepts require relatively accurate movement in space (Potter, 1995). Yet, children with severe impairments often lack the motivation to move in space or are actively discouraged by the physical and social environment in which they live. This further restricts their ability to acquire good concepts about the environment (La Grow, in press). A sighted person is able to take in a whole scene with its landmarks in one view from a distance, whereas the visually impaired traveller is restricted to gaining the

necessary information tactually, kinaesthetically, proprioceptively or auditorially. All of these sources of information require movement. Even hearing requires the student to move in order to verify the source of sound (Hill & Blasch, 1987).

The lack of efficiency in these ways of gaining information is not the only problem; the way that the spatial information is coded and stored in the brain also hinders full understanding (Millar, 1995). Research has shown that everyone uses a number of different modalities to gather spatial information. Each modality has a different specialism and is important for gathering different aspects of the spatial information. Understanding and organising occurs as the different modalities overlap and converge. It is at this point that reference frames for testing concepts and knowledge are built. If one of these modalities is missing, in the case of vision, then the other modalities need to compensate for this and adapt to recreate the convergence and overlap (Millar, 1995). Often this may not occur if the information is not presented in a multi sensory way. It is therefore essential that information is presented to visually impaired children across as many modalities as possible and that it is presented in an assisted and coordinated fashion (Millar, 1995).

Some research also points to the fact that poor spatial organisation may also be related to developmental disorders, prematurity and low birth weight that results in damage to the focal part of the brain. Thus, those with these conditions plus a vision loss may be doubly disadvantaged having a reduction of the use of their primary sense but also their internal referencing within the brain (Stuart, 1995). Children with these difficulties would need information explained and demonstrated in a number of different modalities to maximise the possibility for learning

An O & M programme teaching spatial relations should therefore include information in a number of different modalities. Maps and models are an excellent way of presenting information in a multi sensory way, using visual, tactile and kinaesthetic (ie. requiring movement) elements in combination.

Maps and Models

Maps can come in a range of shapes and forms. They can be purely tactual or designed to be both tactually and visually explored. Some of the most versatile have features suitable for teaching the whole range of blind and low vision students. They may be environmentally specific or generalisable and designed to teach a specific concept or type of layout. Some are static, such as in public buildings. Others are portable for use while walking a route. Some are expensive and designed to be durable and used by a number of students. Others are inexpensive and client specific. The list of possible types is endless and often comes down to the ingenuity or creativity of the individual instructor.

It has been suggested that small scale models are also effective tools for exploring and understanding large scale layouts (Bentzen, 1997; Herman, Herman & Chatman, 1983). Models are three dimensional representations of a large scale environment or object. The best models are those most closely resembling the real object or situation (Bentzen, 1997). Models maintain all the advantages of presenting information in the small scale without complicating the understanding by presenting the information in a two dimensional or symbolic form.

The size of models can vary but is best when designed to make haptic exploration as easy and manageable as possible. A model should be small enough to be manageable and to maintain the advantages of the small scale representation, but large enough for the

detail to be explored. The scale should be as accurate as possible to aid accurate transference of measurements (Bentzen, 1997).

The texture, density and flexibility of materials chosen to make the model should be as close to reality as possible to again help with recognition and development of correct concepts. Pliable floppy roads and soft cars, therefore, may not give good reference clues for the laying down of concepts. If the model is to be used by low vision students then careful choice of colour is important. The colours should be as close to reality as possible but should also provide good contrast to help with visibility. Detail is important to help reinforce good concept development. Too much detail, however, may confuse and a balance is necessary (Bentzen, 1997). If the model is interactive and can be manipulated, play will be facilitated and so greater consolidation of concepts should occur (Recchia, 1997; Bentzen, 1997).

There have been a number of studies that have been undertaken to investigate the use of two dimensional maps and three dimensional models to teach spatial representation to blind and visually impaired children (see Appendix I). Ochaita and Huertas (1993) studied forty blind children to determine the effects of development and learning on their spatial mapping skills. The children were asked to construct three dimensional scale models of routes they had travelled. They found that age was the most significant factor affecting learning of spatial organisation. They discovered that blind children were unable to fully grasp Euclidean concepts until the ages of 14 - 17 years. Likewise, Stuart (1995), in a study of thirty one blind children designed to test a neuropsychological model that included the use of maps and models, found that the grasp of these Euclidean concepts could be further delayed if the child was premature or

had low birth weight. This was primarily due to the higher risk of focal damage in the brain, the area responsible for organising spatial information.

Age was also found to be a significant factor in the study by Ungar, Blades & Spencer (1996) who studied twenty four visually impaired children to determine their ability to estimate distances from tactile maps. They found that only the children over nine years of age were able to use consistent strategies to self locate or trace their route on a map. This follows on from some earlier research they undertook (Ungar, Blades, Spencer & Morsley, 1994) on two groups of blind and two groups of visually impaired children. This study found that the older blind children were considerably better at estimating directions if they had previously explored the map. The younger children were more erratic and needed more specific training. This would again indicate that age was significant in the ability to understand spatial information especially when presented in the format of a map.

An even earlier study by Ungar, Blades and Spencer (1993) on a group of 5 - 11 year old visually impaired children indicated that maps did help them to understand their environment. They also found that, in fact, the totally blind children actually learnt their environment more accurately using maps than they did by direct exploration. Ochaita and Huertas (1993) in their study on 40 totally blind children ranging in age from 9 - 14, found that it was the complexity and not the size of the map that affected their ability to understand the information. The simpler the information the better the understanding.

Bigelow (1991) studied three groups of blind, visually impaired and sighted children asking them to point to a location in a familiar environment. Although her study did not make use of maps or models it is still interesting to note that her findings also indicated that the degree of visual impairment also affected the ability to grasp full

Euclidean concepts. The children were tested over a period of fifteen months to see whether or not they could locate familiar landmarks in relation to themselves. The sighted children had no problems and easily fulfilled the requirements of the test. The visually impaired children all managed to grasp the concepts but some did not achieve this until after a year. None of the blind children tested were able to fulfil all the conditions of the experiment. Therefore, it would appear that the greater the degree of vision loss, the greater the lag in Euclidean conceptual understanding.

Tactile maps do indeed give the visually impaired child a survey, or overall understanding of their environment as they explore them sequentially through touch (Ungar, Blades & Spencer, 1993). Such maps present the information in a small scale and so allow visually impaired people the opportunity to build mental representations of the objects and their relationship to one another through a tactual modality (Ungar, Blades, Spencer & Morsley, 1994).

From these studies, it can be summarised that most children have the potential to successfully use maps to understand spatial concepts. Success in doing so is affected by degree of vision loss and whether or not there has been any focal damage in the brain. Generally, totally blind children could understand environmental concepts more fully from a map although they may not fully grasp all the Euclidean concepts until they are between the ages of 14 -17. Visually impaired children would also be delayed in relation to their sighted peers but should be able to use maps consistently and trace routes at about the age of nine. In all cases it was found that the complexity, rather than the size, of the map affected the children's comprehension.

Blind children under the age of about ten years, however, are unable to express three dimensional objects in a two dimensional way in the same way as their sighted

peers. They perceive the information received through the tactual modality differently and are unable to represent three dimensional objects in a standardised two dimensional way. They also have more trouble understanding symbolic information, another feature of tactile maps. Due to this, the use of tactual maps for representing three dimensional objects or layouts may be inappropriate for visually impaired children under the age of ten (Millar, 1995). However, increasingly complex environments can be understood by visually impaired children as they get older and as they learn the concepts and skills required to represent objects and layouts in a two dimensional format. It is, therefore, important that tactile maps be considered an integral part of mobility training and be introduced as soon as developmentally possible (Ungar, Blades, Spencer & Morsley, 1994). For the actual teaching of concepts, however, other formats such as models may be more appropriate, especially for younger children.

In order to be able to use maps or models successfully the user needs to have a full grasp of Euclidean principles and be able to transfer information across scales (Potter, 1995). As we have seen from the studies reviewed above, the age at which this is possible will depend on the degree of visual impairment. Visually impaired children, however, also invariably have a lag in their ability to assimilate new information into their existing ideas (Potter, 1995). This may cause trouble when attempting to use geometric reasoning to transfer knowledge across scales, as well as when transferring distances from map to reality (Potter, 1995). Techniques of ratio estimation may need to be specifically taught to assist in this transference of knowledge (Ungar, Blades & Spencer, 1997).

Some research has shown that visually impaired children can perform large scale tasks better than small scale tasks but this is primarily due to the fact that the large scale

task often utilise more primitive concepts (Potter, 1995). The performance of a route, for example, need not use Euclidean concepts since the route can be learned and executed in a sequential way. The planning of a route, however, would need Euclidean concepts and may not so readily be executed. It is therefore necessary to carefully assess whether these concepts have been grasped, rather than the child using more primitive concepts to solve the problem (Potter, 1995). When testing, it is often useful to use direct and indirect measures to ensure that the knowledge has to be applied rather than just carried out (Potter, 1995). Also, the observation of play situations may help to confirm that a concept has been grasped since play allows the child to explore and experiment, often generalising the information learnt (Recchia 1997).

All this may lead to visually impaired children understanding a concept on the small scale representation but not being able to transfer this to the large scale (Potter, 1995). Therefore, when maps or models are used it is also important to include large scale experiences as well, to supplement and confirm knowledge gained in the small scale representation (Potter, 1995).

The purpose of this study, therefore, is to test the efficacy of using an interactive three dimensional model to teach environmental concepts to visually impaired children. The degree of efficacy will be demonstrated by assessing, with a large scale environmental probe, the children's understanding of the concepts taught via the model to determine whether and to what degree these concepts are being transferred to the real environment.

Method

Materials

A three dimensional, interactive, wooden model was developed as a tool for teaching environmental concepts to children with a visual impairment. It consists of eighty three pieces representing roads, footpaths, grass verges, crossings, intersections and traffic controls devices, as well as, wooden blocks to represent houses and buildings (see Appendix II). The pieces may be assembled by the child or teacher to form a number of configurations for (a) exploring various environmental concepts (b) modelling specific environmental features, or (c) constructing routes and/or neighbourhoods. Matchbox cars and Lego figures were added to represent pedestrians and automobile traffic. The Lego figure was also used to represent the child's relative position in the environment.

Subjects

Four students were asked to participate in this study . All had some degree of visual impairment, attended Central Normal School in Palmerston North, New Zealand and were between the ages of seven and eleven. This age group was chosen as it seemed an age appropriate level to teach these concepts. There were two boys and two girls.

Subject 1 was a seven year old girl who has had a number of strokes causing a right haemianopia. Her distance acuity is 6/60 with reduced left side fields and she reads N36 print. She has normal intelligence and some right side weakness. Subject 2 was an eight year old boy of normal intelligence with ocular albinism who has no other problems. He has a binocular distance acuity of 6/60 and reads N12 print. Subject 3 was a nine year old boy with optic nerve hypoplasia. He has some light projection and colour vision in his right eye. He is a Braille reader and cane user. He has normal intelligence and no other complications. Subject 4 was a ten year old girl with optic

atrophy. She has distance vision in her left eye of 6/36 and in her right eye of 3/60. She reads N16 print. She also has normal intelligence and no further problems.

Procedure

Prior to the introduction of the model all the children were tested to see if they knew the prerequisite concepts required. These included body, positional, directional and shape concepts. A full list of these concepts can be found in Appendix III. The Orientation and Mobility Concept Assessment test used to test knowledge of these concepts, is contained in Appendix IV. The assessment identified a number of gaps in knowledge across the children. Subject 1, for example did not understand upward, across from and round. Subject 2 did not understand sideways. Subject 3 did not understand X and Y shapes. Subject 4 did not understand across from and round. They all were unsure of the 15 directional concepts of (a) straight, (b) diagonal, (c) horizontal, (d) vertical, (e) parallel, (f) perpendicular, (g) centre, (h) north, (i) south, (j) east, (k) west and (l) turns (360, 180, 90 and 45 degrees). Since these had all been identified as prerequisite skills, they were then taught to the subjects before commencing the study. A number of different teaching strategies were used including, "Simon Says", "Hide and Seek", "Hide and Seek with objects", "Shape Matching games", "Jigsaw Puzzle Match", "Musical Shapes", "Throw and Turn game", "Directional Checkers" and "Where am I". This teaching was undertaken by a student teacher of the visually impaired who designed many of the games herself. When all the prerequisite concepts were understood, the research programme for this study was initiated.

The environmental concepts that were to be taught were identified and placed into three sets (see Appendix V). The programme was then designed to move from an egocentric base to self to object and then object to object base (Wadsworth, 1971). It

was also designed to introduce concepts requiring concrete knowledge to those requiring functional knowledge and then those that needed to be generalised across different environments and circumstances (Gibson, 1967; Zweibelson & Barg, 1967).

Set one consisted of environmental objects and included the following 20 concepts; (a) road, (b) footpath, (c) grass verge, (d) kerb, (e) gutter, (f) inner shoreline, (g) outer shoreline, (h) traffic, (i) pedestrian, (j) cyclist, (k) left hand side of the road, (l) central line, (m) driveways, (n) pram ramp, (o) blended kerb, (p) park, (q) give way sign, (r) stop sign and (t) traffic light.

The second set consisted of environmental concepts and included the following 21 concepts; (a) one way traffic, (b) two way traffic, (c) traffic lane, (d) street corner, (e) block, (f) parallel traffic, (g) Perpendicular traffic, (h) pedestrian crossing, (i) intersection, (j) give way, (k) stop, (l) T intersection, (m) X intersection (Uncontrolled), (n) X intersection with give way and stop signs, (o) right of way, (p) roundabout, (q) X intersection with traffic lights, (r) safety island, (s) angle parking and (t) straight parking.

The third set concentrated on route planning and execution and included the following 10 concepts; (a) cardinal directions, (b) directional corners, (c) landmark, (d) clue, (e) reference point, (f) destination, (g) straight line route, (h) L route, (i) Z route and (j) plan and execute a route (Euclidean concepts)

A changing criterion design was used to demonstrate the children's knowledge of the environmental concepts that were taught on the model. The teaching was done one set at a time. The number of concepts, correctly demonstrated three times, was recorded after each lesson. Instruction continued in each set until knowledge of all concepts in that set were demonstrated. The next set was only introduced after this was achieved. Thus, the criterion for moving from one set to the next was set at 20 and 41 concepts

correctly identified respectively. Each child's progress was recorded and their movement through the teaching programme individually determined.

An environmental probe was used to test the child's knowledge of these concepts prior to the introduction to the model and after competency with each set of concepts was demonstrated. The probe assessed 38 environmental concepts arranged in an assumed hierarchy of understanding that roughly corresponded with the 51 concepts introduced with the model. A full list of these concepts and the questions used to test knowledge of these concepts can be found in Appendix VI. The discrepancy in the number of concepts assessed with the model and those with the probe was due to a need to ensure that the students understood the representation and terminology utilised in the model but not directly assessed in the environment. The former included eight concepts used in naming or identifying environmental objects (ie., vehicles, pedestrian, cyclist, park, traffic lane, give-way sign, stop sign and traffic light) and five required for teaching the concepts involved in route planning (ie., cardinal directions, landmarks, clues, references and destination). Knowledge of these 13 were indirectly assessed in the probe.

Each concept correctly identified in the probe was recorded. Assessment was discontinued when two consecutive concepts in the hierarchy were missed or incorrectly identified. Thus, the environmental probe represented the number of concepts correctly identified in a row.

The students were seen in age group pairs for 30 minute lessons once a week. The lessons were conducted by an O & M instructor in the classroom with the aid of an assistant. No instruction was provided in any other environment or format. All concepts were introduced using the model. The children were encouraged to manipulate pieces,

construct environments, demonstrate traffic flow and rules and plan and execute routes. The latter was demonstrated using Matchbox cars and Lego figures.

Reliability

A secondary observer was present to observe each of the four subjects on one of the four environmental probes (ie. 25%). Each observer recorded the number of concepts correctly identified in a row. The lower number was divided by the higher number for each subject. The quotient was multiplied by 100 to establish a percent of agreement using the following formulae.

$$\%IOA = \text{lower/higher} \times 100.$$

The IOA for each subject was obtained, summed and divided by four (ie., the number of subjects observed) to obtain a mean IOA. A range was then obtained by noting the lowest and highest %IOA obtained.

Results

The mean IOA was 89% with a range from 79 to 94%.

As can be seen in Figure 1, subject 1 required two training sessions to reach competency in the first set, three for the second and four for the third. She had most trouble with the concepts for directional corners. She demonstrated knowledge of four concepts in the initial environmental probe, fifteen in the second, twenty six in the third and thirty five in the final probe. There were three concepts she was unable to demonstrate knowledge of the L route, the Z route and the execution and planning of a route in the final probe.

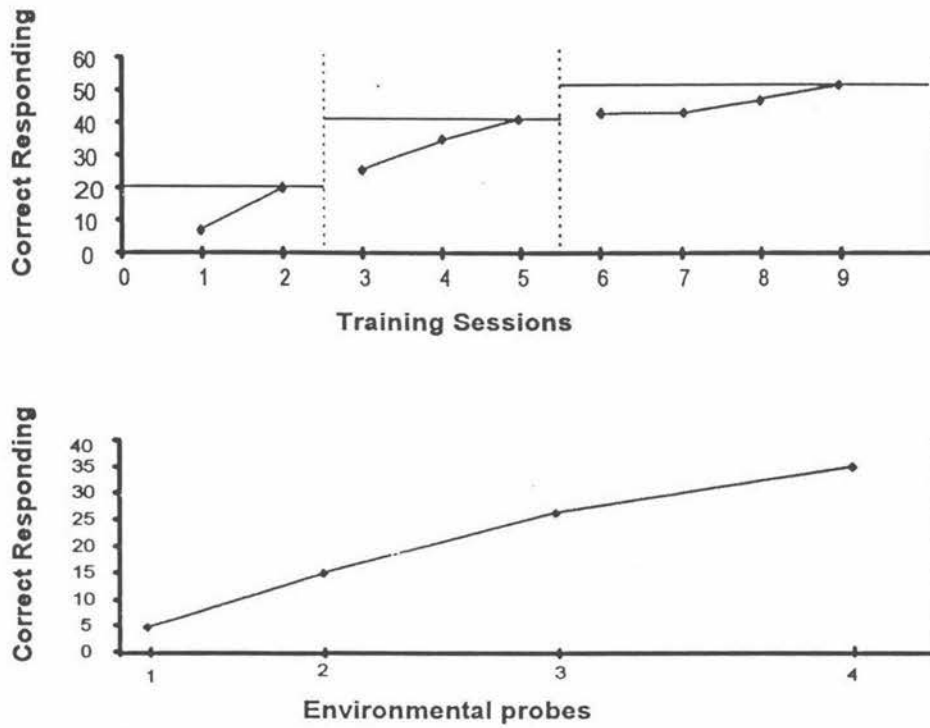


Figure 1 : Number of correct responses for training sessions and environmental probes for subject 1.
Solid horizontal lines indicate criterion for each phase.

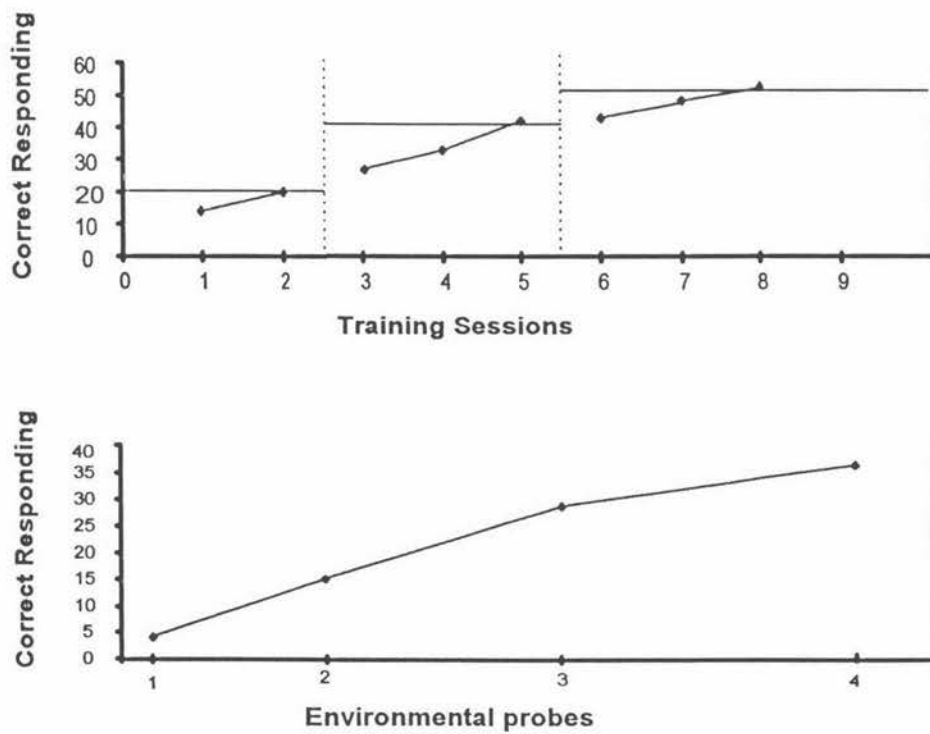


Figure 2 : Number of correct responses for training sessions and environmental probes for subject 2.
Solid horizontal lines indicate criterion for each phase.

As can be seen in Figure 2, subject 2, required two training sessions to reach competency on the first set, three for the second and three for the third. The environmental probe showed that before training he was able to demonstrate knowledge of four of the concepts this increased to fifteen in the second, twenty nine in the third and thirty seven in the final probe.

As can be seen from Figure 3, subject 3 required two sessions to demonstrate competency on the first set of concepts, three for the second and four for the third. In the probe, he was able to demonstrate knowledge of six of the concepts before training started. This increased to eighteen in the second probe, twenty nine in the third probe and thirty six in the final probe.

As can be seen in Figure 4, subject also required two training sessions to demonstrate competency on the first set, three for the second and two for the third set. She demonstrated knowledge of six concepts in the environmental probe prior to training. This rose to nineteen in the second probe, twenty nine in the third and thirty eight in the fourth probe. She was the only subject to demonstrate all the concepts in the environmental probe.

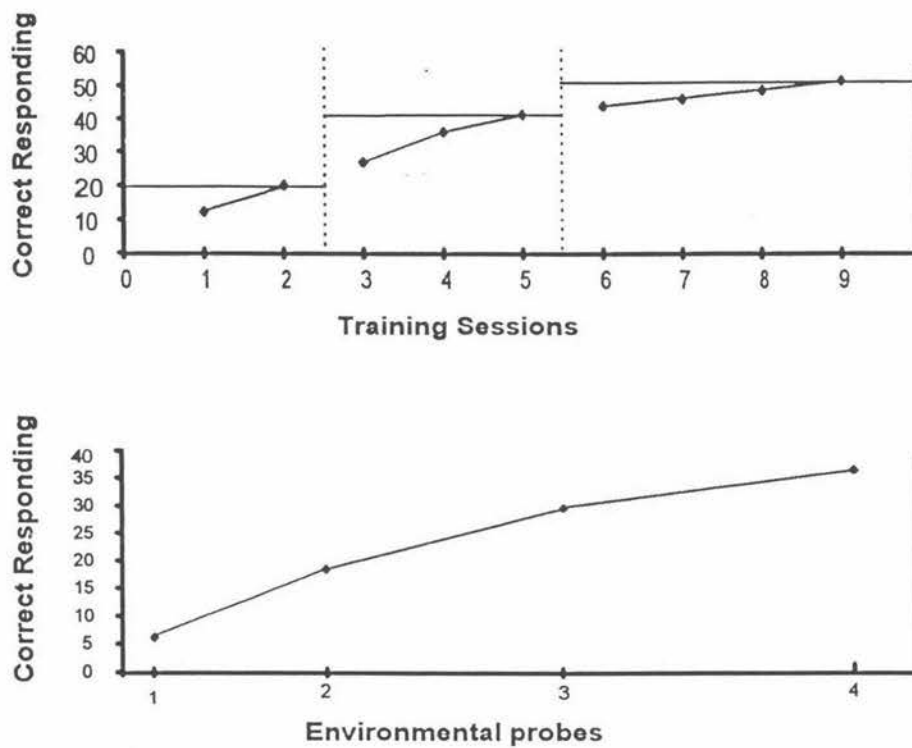


Figure 3 : Number of correct responses for training sessions and environmental probes for subject 3.
Solid horizontal lines indicate criterion for each phase.

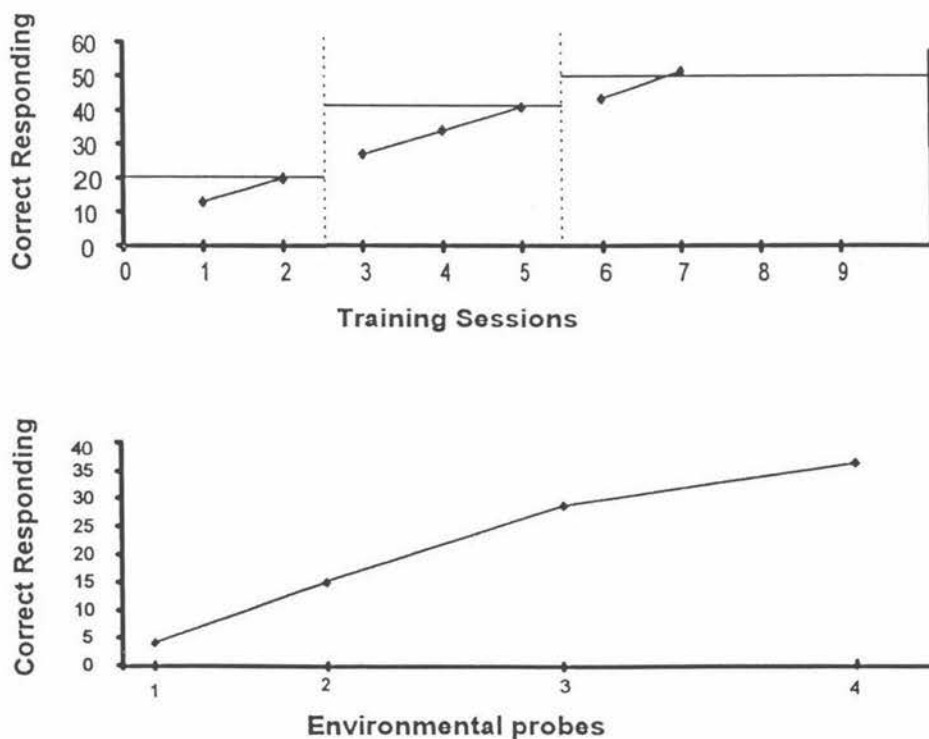


Figure 4 : Number of correct responses for training sessions and environmental probes for subject 4.
Solid horizontal lines indicate criterion for each phase.

Discussion and Conclusions

From the results of this study, it can be seen that all the subjects required only two teaching sessions to demonstrate competency in the first set of concepts and three for the second set. The number of teaching sessions varied for the last set, subject 4 required only two, subject 2 required three and subjects 1 and 3 required four. It is interesting to note that subject 1 was the youngest, subject 4 was the eldest and subject 3 had the greatest vision impairment.

It is also interesting to note that these results were reflected in the probe. All the subjects started in a similar range, the two youngest demonstrating knowledge of four concepts each and the eldest six each. Results of the probes at the next stage were again similar with the two youngest demonstrating understanding of fifteen concepts and the two older subjects demonstrating eighteen and nineteen respectively. The results for probe three were interesting with the three older subjects demonstrating twenty nine concepts and the youngest only twenty six. This would appear to indicate that as the concepts became more complex age became more significant. The last probe also supports this theory as the only subject to demonstrate an understanding of all the concepts, including the Euclidean concepts, was subject four, who was not only the eldest but also the subject with the most vision. The youngest subject, subject 1, demonstrated the least knowledge in the probe followed by subject 3 the subject with the least amount of vision.

The results of this study demonstrated the efficacy of the model for teaching environmental concepts to the four visually impaired children. It also confirmed previous findings that age and degree of vision impairment significantly affected a child's ability to understand full global Euclidean concepts.

It is important to note that all the instruction was done in the classroom and limited to the use of the model. No supporting work was done in the actual environment. This was done to ensure that the generalisation of concepts from the model to the actual environment was not due to any other interventions. It is, however, noted that best practice and previous studies would suggest that small scale teaching should be reinforced with experience of the large scale. For this reason it is suggested that the concepts taught with the model in the classroom be reinforced with experiences in the actual environment.

There are a number of other teaching considerations that are highlighted from previous research and this study that need to be applied if the model is used in a programme to teach environmental concepts. Before a programme is started, the students should be assessed to ensure that they have all the prerequisite skills and concepts needed to enable them to understand the concepts presented in the programme (Wadsworth, 1971). Allowances also need to be made for the possibilities of some totally blind children having focal brain damage which could seriously affect their ability to organise spatial information. Additional strategies or more realistic goals may need to be set (Stuart, 1995; Bigelow, 1991).

Testing should occur repeatedly throughout the programme to ensure that the concepts have been completely grasped and not just verbalised (Hill & Blasch, 1987). Indirect testing of concepts and the use of problem solving or planning exercises can also be used to ensure that the more generalised or Euclidean concepts have been understood and utilised (Potter, 1995). Observation of play is another means of testing, since problem solving and the use of complex concepts can be monitored (Recchia, 1997). Teaching sessions can thus be usefully supplemented with play activities. If concepts are

reinforced through play situations a greater understanding of non literal and hypothetical situations can be explored. This may lead to a greater ability to generalise concepts and construct meaning. If the child can interact with and manipulate the model in their own time and space a fuller understanding of the concepts will most likely occur (Recchia, 1997).

The use of a model has a number of advantages over teaching in the environment alone. It allows those with considerable vision loss to explore road layouts and demonstrate traffic flows and routes tactually, something impossible in the actual environment. Low vision children can also visually explore the model more efficiently in the small rather than the large scale.

The main advantage, however, that a model has over tactile maps is that learning is simplified by reducing the complexity, as no change of dimension (3 to 2 D) or symbolic representation is required. This would mean that a model could be introduced at an earlier age and may ease the transition to later use and training of routes and environments on tactile maps (Bentzen, 1997).

Some of the previous research by Ungar, Blades and Spencer (1993) showed that the totally blind child learnt the environment more accurately using the small scale rather than through direct exploration. This would certainly be true of a model and may prove invaluable for the teaching or confirming of Euclidean concepts.

The model used in this study is very portable coming in a convenient tool box and is therefore easy to transport allowing the model to be used within a school or home environment. It is flexible enough to allow the child and teacher to build a whole range of different layouts, some of which may not be available in the local vicinity. It allows the children to explore traffic conditions and environmental layouts in a safe and convenient

way. Another advantage is that it allows the child to explore and develop experiences in a safe way. Mistakes do not have the same consequence that they may have in the actual environment. The model is also very similar to toys on the market and is therefore perceived as fun to 'play' with.

The main advantage of this model is that it is interactive and can be manipulated by the children thus facilitating consolidation of concepts through play. This model can be used to build environments and environmental features as well as to demonstrate them. Routes can be planned and demonstrated on the model using Lego people or other figures. The children may move these figures around showing the teacher the streets they expect to walk along, the sides of the street they expect to be on, where they expect to cross streets, the type of intersections they expect to encounter and where they expect to find their destinations.

The complexity of the environments can be expanded as the child's understanding expands. It is possible to start with simple street and block configurations and move to more complex designs. Specific environments can also be modelled.

It can be seen that the possibilities for teaching using this interactive three dimensional model are numerous. It provides a tool that is both adaptable and efficient, as well as, fun to use. It can become a primary tool for teaching environmental concepts and as a prerequisite for the introduction of tactile maps.

This study has used a single case research design. This type of design has certain advantages and disadvantages. One of the main advantages is that one can see the direct result of an intervention. In this particular study it was possible to see how each subject was able to demonstrate the concepts taught, and generalise them to the actual environment. Areas could be identified where difficulties occurred or where further

training was necessary. The design is also appropriate to the individualisation of teaching strategies used with this population. Educational programmes are individually designed for these children as should be interventions and teaching strategies. Therefore, a single case design has heuristic value and is seen as an appropriate method to use.

One of the limitations of this type of study is that it is very case specific. The results cannot be generalised across similar populations. It may, however, be possible to put forward some hypotheses, based on the results of this study, as a basis for further study.

As with any research there are always areas of weakness. In this study some of the weakness are related to how the research was conducted. Although a concept was only marked as being understood if it was demonstrated three times, it would have been more conclusive if training had continued until the subjects had acquired 100% over two or more training sessions. This may have further demonstrated control of the design and whether or not an inability to demonstrate the concept in the probe was due to a lack of conceptual understanding or an inability to transfer that knowledge from the model to the real environment. Reliability of the results is always important and for this study verification was only undertaken on one probe or over 25% of the results. It would have been preferable to have run reliability tests over a third of the probe.

A number of interesting points have been highlighted by this study including the confirmation of previous research. Much of the current research relates to spatial representation and tactile maps but this study has shown the potential for more research concerning models and environmental concepts.

Further research could concentrate on a number of different aspects. A study could be undertaken to determine whether maps or models are the most effective for

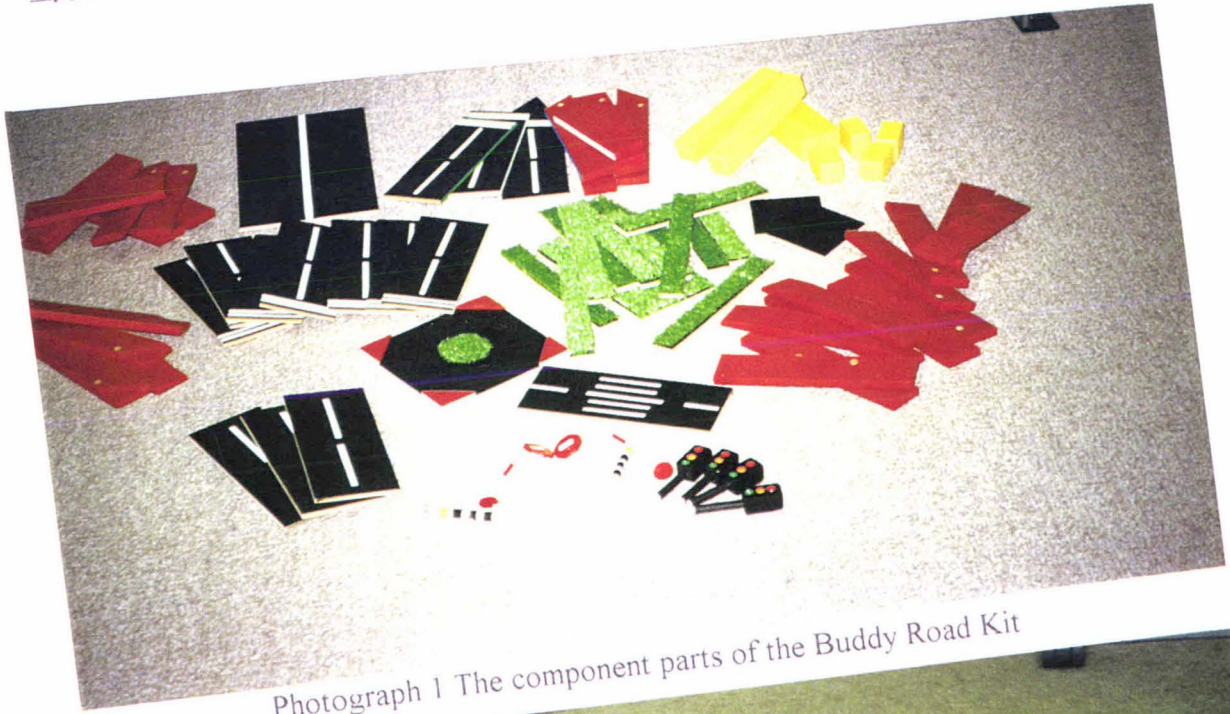
teaching environmental concepts. The question of whether a child's ability to use tactile maps was enhanced by previous experience of models could be investigated. Further research could be undertaken to determine if a child's ability to understand environmental concepts was enhanced by concurrent model training and experience in the actual environment.

Appendices

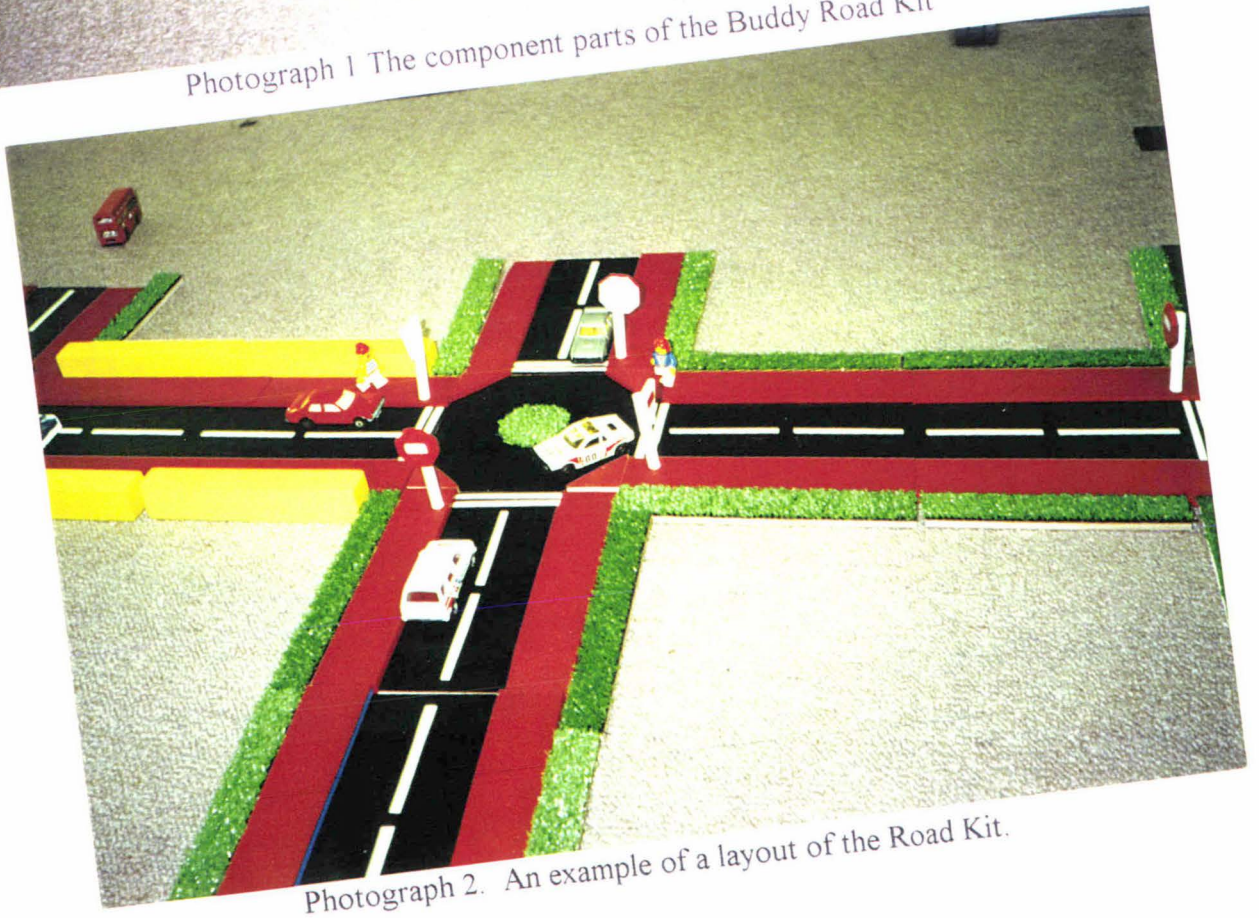
Appendix I. Studies investigating spatial and environmental concepts.

Author	Year	Subjects	Purpose	Conclusions
Ochaita & Huertas	1993	40 totally blind children divided into four age groups. Average ages in each group were 9, 11, 14 and 17 years of age.	To determine the effects of development and learning on the blind child's ability to construct models of routes and estimate distances.	Age plays the most significant role while learning is secondary to the development of spatial representation in the visually impaired. It is between the ages of 14-17 that totally blind children are able to fully develop the abilities to represent a known environment. It is complexity of space rather than size that determines the level of representation.
Stuart	1995	31 Congenitally blind children.	To test a Neuropsychological model for determining spatial orientation in the absence of vision. The model consisted of tests using spatial orientation, 3D construction, tactile maps, tactile to locomotor tests, and the Lorrimer test of Braille reading.	Tactile maps tests and 3D construction tests were good indicators of a child's understanding of spatial orientation. There is a close association between Braille reading and spatial orientation. Developmental disorders together with premature birth and low birth weight, increase risk of focal brain damage. This can lead to a reduction in the ability to organise spatial information in the brain.
Ungar, Blades & Spencer.	1993	Visually impaired children between the ages of 5-11 years of age.	To determine whether the use of tactile maps assisted visually impaired children to understand their environments.	All the visually impaired children could understand and use the map. The totally blind children learnt the environment more accurately using the map than through direct exploration.
Ungar, Blades, Spencer & Morsley	1994	Two groups of blind children one older one younger and two groups of visually impaired children one older and one younger.	To determine if visually impaired children could use maps to estimate directions.	Untrained totally blind children could estimate directions much more accurately if they explored the map first. The younger children were, however more erratic and needed further training in map skills.
Ungar, Blades & Spencer	1996	26 visually impaired children.	To determine the self location skills of the subjects using a large scale environment and a tactile map.	The majority of the subjects could self locate using the tactile maps. The older children, average age nine were also able to trace their route on the map and utilise consistent strategies to do so.

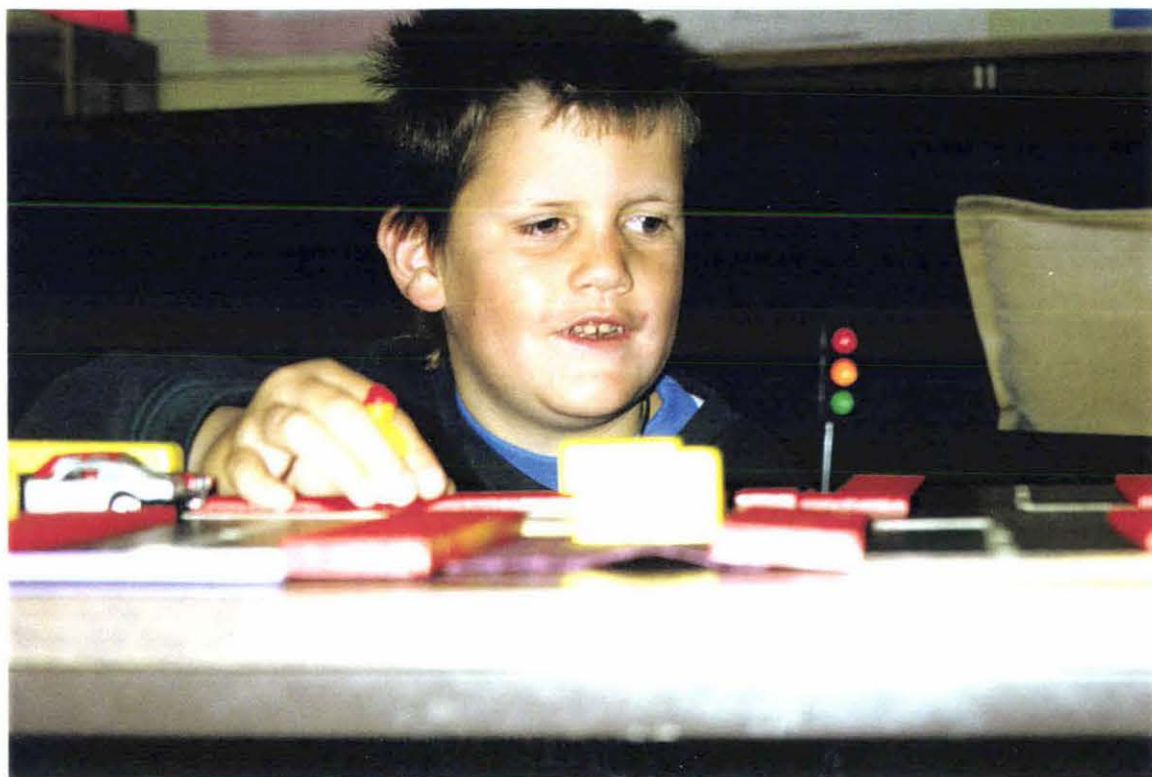
Appendix II. Photographs of the Buddy Road Kit.



Photograph 1 The component parts of the Buddy Road Kit



Photograph 2. An example of a layout of the Road Kit.



Photograph 3. A lesson showing the interactivenss of the Road Kit .



Photograph 4. Showing how the Road Kit can be manipulated by children

Appendix III. Prerequisite concepts

Hierarchy of Environmental Concepts

Pre -requisite Level:

Body, Spatial, Positional, Directional and Shape Concepts.

Concepts to be learnt at this stage:

Body:- head, face, eye, ear, nose, mouth, body, leg, foot, knee, arm, hand, finger, elbow, shoulder, bottom, side, back, stomach, tummy, waist, sit, stand, lie down, touch, point, bend, lean

Spatial:- front, in front of, face, facing, forward, before, ahead, back, behind, backward, top, above, over, up, high, upward, bottom, below, under, down, low, downward, beneath, underneath, next, next to, beside, right, left, sideways, alongside of, away, far, farthest, near, nearest, here, there, against, into, in, inside, out, outside, around, between, end, opposite, across from, toward, middle, on, off.

Shapes:- Round, circle, triangle, rectangle, square, shapes of letters T, X, and Y.

Directional:- straight, diagonal, horizontal, vertical, parallel, perpendicular, centre, north, south, east, west, Turns (360, 180, 90 and 45 degree turns) quarter, half, whole,

Teaching Strategies.

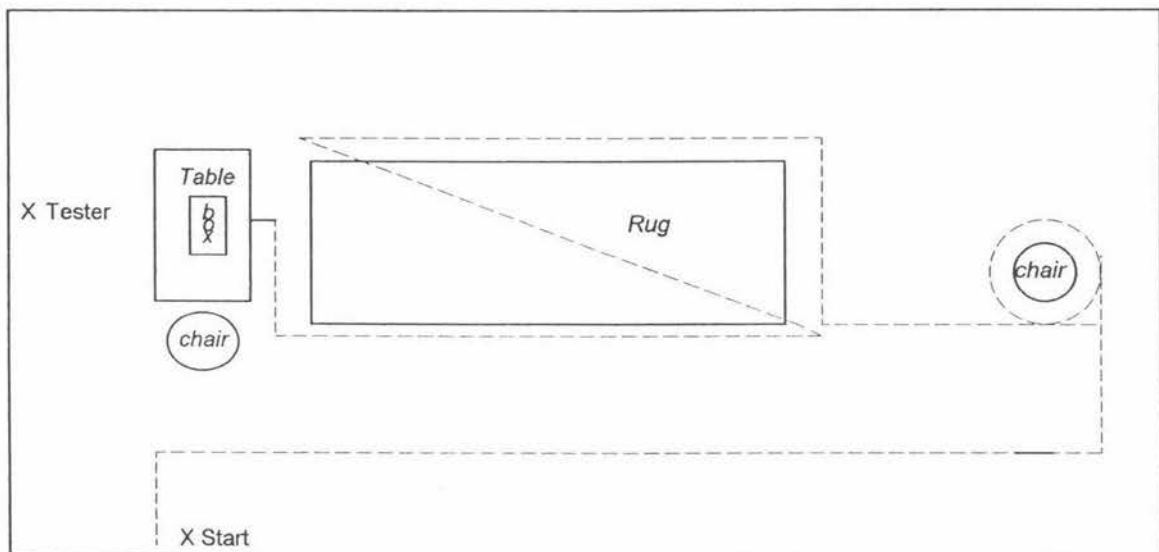
Simon says game. Hide and Seek. Hide and Seek with objects. Treasure Hunts. Shape matching games.

Appendix IV. Test for prerequisite level

Orientation and Mobility Concept Assessment.

Adapted from the work of Margaret Hutchinson, Los Angeles County Superintendent of Schools.

Run it like a treasure hunt with a prize at the end.



Layout: As above.

Equipment: One rectangular table, two chairs, one small box, large rectangular mat, shapes, (circle, square, rectangle T, X and Y shapes) and one prize.

Instructions.

Walk forward. Stop.

Turn right

Go forward to the wall

Touch the wall with your hand

Put your back against the wall
Put your left side against the wall
Put your right side against the wall
Walk next to the wall
Go to the chair
Go right around the chair
Face me
Touch the top of your head
Touch your foot
Touch the back of your head
Touch the side of your body
Touch the bottom of your foot
Touch your front
Hold up your left hand
Touch your back
Walk backwards away from me. Stop
Walk forward toward me. Stop.
Lie down on your back
Lie on your stomach or tummy
Stand up
Step sideways to your right
Lean backwards
Bend forwards
Walk straight ahead to the mat.
Turn 90 degrees
Walk to the corner of the mat.
Walk diagonally across the mat
Turn 45 degrees to your right.
Walk parallel to the edge of the mat. Stop
Walk perpendicular to the edge you have just been walking along
Stop
Do a 360 degree turn
Do a 180 degree turn
Do a half turn
Do a whole turn
Pick up the stick in front of you
Hold it so it is vertical

Hold it so it is horizontal.
Put the stick behind you.
If you are facing north at the moment
Turn to face south.
Turn to face west
Turn to face east
Go to the table
On the table is a box
Take the shape pieces from the box
Find the circle and place under the table
Find the square and place in front of the box
Find the triangle and place inside the box
Find the rectangle and place under the box
Find the T and place behind the box
Find the X and place to the left of the box
Find the Y and place to the right of the box
Put your right side against the table
Walk to the end of the table
Point to me
Point down
Point up
Hold up your right hand
Go to the chair on your right
Sit on the chair
Put your hands between your legs
Stand behind the chair
Touch your right knee
Touch your left arm
Touch your right leg
Bend over slowly and touch you left foot
Touch you left ear with you left hand
Touch your right shoulder with your right hand
Touch your eye, nose and mouth in that order
Touch your left knee with your right hand.
Find box under chair
Take prize out of box
Finish

Appendix V. The three sets of concepts taught on the model

Set 1. Environmental objects

Object recognition.

road, footpath, grass verge, kerb, gutter, inner shoreline, outer shoreline, traffic, pedestrian, cyclist, left hand side, central line, driveways, pram ramps, blended kerbs, park, give way sign, stop sign, traffic light (20 objects)

Teaching strategies. Simple recognition of parts in the road kit and their relationship to each other.

Test: All concepts will be taught until 100% accuracy has been reached. 100% accuracy is considered as being able to demonstrate the concept three consecutive times.

Set 2: Environmental Concepts and Traffic Flows.

Concepts to be learnt at this stage including rules and patterns.

Two way traffic (travel on left side of road), one way traffic, traffic lane, block, street corner, parallel traffic, perpendicular traffic, intersection, T intersection, X intersection (uncontrolled), X intersection with give ways and stops, roundabout, X intersection with traffic lights, safety island, angle parking, straight parking, give way, right of way, stop pedestrian crossing and school crossing 21 concepts)

Teaching strategies: Use the kit to explain the concepts. Use the manual for ideas.

Test: All concepts will be taught until 100% accuracy has been reached. 100% accuracy is considered as being able to demonstrate the concept three consecutive times.

Set 3 Route Planning and execution.

Concepts to be learnt at this stage

cardinal directions, directional corners, landmarks, clues, reference points, destination, straight line route, L route, Z route plan and execute a route (Euclidean concepts. (10 concepts)

Teaching Strategies. Use the road kit to build a familiar environment. Explain concepts. Use the layout to plan and execute straight line, L shape and Z shape routes, using reference points, landmarks, clues and destinations. Get the student to plan and execute a route on the road kit

Test: All concepts will be taught until 100% accuracy has been reached. 100% accuracy is considered as being able to demonstrate the concept three consecutive times.

Appendix VI. Environmental Probe

Environmental Probe

Test Area: Test area near to school and the areas locally that suit the road concept being tested.

Instructions.

Stand on the footpath

Face the road

Walk to the kerb

Place a foot in the gutter

As we cross the road tell me when we cross the centre line

Tell me when we reach a blended kerb

There is a pram ramp at the corner go and stand on it

Tell me when we get to a driveway

Stand on the grass verge

Go to the inner shoreline

Go to the outer shoreline

Tell me when you can hear traffic

Point to the direction the traffic is coming from

Go to the kerb and face the traffic. If this was a one way street which direction would the traffic be coming from
This is a two way road which direction would the traffic be coming from on the side of the road closest to you. Farthest from you.

Which side of the road do we travel on in this country and how do we work this out.

Tell me when we get to the pedestrian crossing. Show me the direction the traffic can come from. How do you know when it is safe to cross

After school this becomes a school crossing. What changes. How do you know when it is safe to cross.

Walk to the street corner.

You are standing on the corner of a block. How many corners would you have to go around to come back here. How many roads would you cross.

Face one of the roads. Show the direction of traffic flow that is parallel to you.

Show the direction of traffic flow that is perpendicular to you

What is an intersection. Take me to one.

What shape is a give way sign? What does it mean

What shape is a stop sign and what does it mean. How does it differ from a give way sign

Which type of intersection are we at (T). Explain the direction of the traffic flows by pointing to the direction of flow and explaining the side of the road either as nearest or farthest from you.

Which type of intersection are we at (X uncontrolled. Explain the direction of the traffic flows by pointing to the direction of flow and explaining the side of the road either as nearest or farthest from you.

Which type of intersection are we at (X with give ways and stops). How does this differ from the previous intersection. Which cars could go first the ones at the give way or the ones at the stop.

What does it mean if a car has right of way.

Which type of intersection are we at (roundabout) How does this differ from the previous intersection. Point in the direction of flow of traffic around the roundabout. Which car would have to give way to which (give car placements).

If there is a safety island in the centre of the road which traffic flow do we have to think about as we start to cross the road. Tell me when we reach the safety island. Which traffic flow do we have to concentrate on next.

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