The Design Process of a Toy with Educational Objectives for Blind and Visually Impaired Pre-school Children

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The Design Process of a Toy with Educational Objectives for Blind and Visually Impaired Pre-school Children: A Design Process Model for Problem Identification, Novel Concept Development, and Frequent Involvement of the User Group

A PhD Thesis

Submitted by

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to

Kent Institute of Art & Design/University of Kent at Canterbury

in Partial Fulfilment for the Degree of Doctor of Philosophy in Industrial Design

KIAD/UKC

September, 2002

ABSTRACT

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The thesis investigates design methods and phase models towards a reinterpretation of the design process towards a specific design task. The study reveals the essence of the process as a *design process core*, onto which may be built *design process models* to suit design tasks of diverse nature and scale. The role of the designer is underlined as, not only the person who carries out the creative act of designing, but as who employs knowledge and skills in devising own process model towards carrying out a design task, aiming at a product, honest to its purpose. The *design process core* is then built into a *design process model* for the particular design task of *designing a toy for blind and visually impaired pre-school children*. The model is devised with the particular aims of *identifying a problem area, developing a totally novel concept*, and *frequently involving the user group throughout the process*.

With this approach to the design process, it is argued that, the designer, aware of the responsibility of his/her actions and decisions in the forming of a culture of living, identifying a socially relevant area of design, may work towards an output/product, to become a responsible part of the life system of the particular user groups. The design process model is then employed in the designing of a toy with educational objectives, embodying intense research and generation of ideas. The outcome of the process is field tested in a playgroup in the Kent area. The results of the field test contribute to further improvements on the design decisions. The model is assessed as to: its organising of collaboration within the process, systematic accumulation of research findings towards a design output, implications on the field of design methodology; and implications of the outcome of this particular application on the specific user group. Further areas of research are suggested.

Keywords: Design; Design methods; Phase Models; Blindness and Visual Impairment; Development and Play Behaviour of Blind/ Visually Impaired Children; Toy; Play; Design Process Core; Design Process Model.

ACKNOWLEDGEMENTS

This thesis would not have been concluded without the guidance of my lead supervisor Dr Tevfik Balcıoğlu. I thank him for his support and confidence in me. I would also like to thank my supervisor Prof Glynis Murphy. I have always looked forward to our tutorials, all of which have proved most inspiring towards the shaping of the thesis.

I have contacted many persons during my research, and they all have been most welcoming and helpful. I would particularly like to express my gratitudes to these persons who have been ever so patient with my study. I would also like to thank Refik Toksöz for sharing with me his skills of computer modelling and animation.

I would like to thank Jane and John Sell who have been wonderful friends and hosts during my stay in the UK, for introducing me to the English culture and showing me around the country.

I would like to thank my mother and father for being there when I needed them most, and for their financial support. I would also like to thank the many friends I have made here, and Esra Kıygı in particular. The strong friendships we have built with people from such different cultures and far away countries have proven that 'college years' are unforgettable.

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1. INTRODUCTION

> 'Design is as much an expression of feeling as an articulation of reason; it is an art as well as a science, a process and a product, an assertion of disorder and a display of order. By learning to look insightfully at the array of designed objects, services, and techniques in society, we can begin to recognise the manifestations of social values and policies (Margolin, 1989:28).'

> 'When manufactured, (...) a design as a tangible artefact becomes part of the physical reality of its time, applied for specific purposes in a society that conditions how its form is perceived and evaluated. This evaluation may be based on premises different from those of the designer and producer, and it will be argued that the values attributed to designs in their social function are not fixed and absolute, but fluctuating and conditional (Heskett, 1987: 9).'

1.1. DESIGN AS A SOCIAL RESPONSIBILITY

As a tool in the social expression of values and culture, design and industrial design in particular, has played a strong role in the shaping of environments and lifestyles, and in time has united societies of the world, with a common culture of objects.

Margolin (1989) argues that, the role design has in society is still not well conceptualised, and whereas design theories have largely focused on refining methodology, how design operates on society has been neglected. As Whiteley (1998: vii) points out, ' (...) there is a direct (and inevitable) link between a society's design and its social health: design is a manifestation of the social, political and economic situation (...)'; on the basis of many social problems, lies the 'design boom'.

Since the Second World War and following the modernist era that supported a standardised and styleless environment with objects only reflecting their material and construction, good industrial design has been mainly associated with mass acceptance from the market; the consumer, not satisfied with impersonal design, the incorporation of fashionable aesthetics, technological progress, and the popular tastes and desires became a major concern for businesses (Whiteley, 1998). Particularly since the 1980s, businesses have involved consumer interests and demands in their strategic planning, and with heavy marketing strategies, have determined almost in artificial terms, the social trends and desires through their life-style products. The businesses in the 1990s had to face fierce competition, which led them to shorten the time spent on product development, using methods in the product development processes to that end. To keep up profits in this fast pace, required fast changes in preferences that soon change as new products appear; with products of short lifespans, bringing 'disasterous' consequences, not only in ecological terms with pollution, waste of resources and generated debris, but also in economic and social terms. It has been pointed out that, societies face a distasteful, and irresponsible lifestyle with the imposed design products; and resources are wasted on profit-concerned product development, rather than being invested on designs that could improve the quality of lives of societies' various participants.

> 'You have power in the marketplace only if you have sufficient money; many groups in society – from disabled groups and elderly people, through to a significant percentage of ethnic minorities, to the growing 'underclass' - have a minimal income (let alone any disposable income) and so are excluded from the marketplace. Consumer-led design does not – and cannot - deal with the needs of these people because there is no profit in them (Whiteley, 1998: 42).'

Debates, particularly on the dangers of corruption in materialism, and the ecological consequences felt particularly since the 1970s, criticise design for being mostly associated with businesses, profit, obsolescence, and materialism, shadowing the social responsibilities it ought to have. As materialism became a major directive issue in industrial design, alongside it developed a movement that saw design as a socially and morally improving factor; social acts and action groups pioneered by designers throughout the world gave their support for *designing responsibly*, towards issues such as cheap transport, low-cost energy, technical support for the disabled, and such products that answered needs of diverse minority user groups (Whiteley, 1998). In 1974, Papanek's book *Design for the Real World*, strongly criticised the irresponsible understanding of and materialistic approach to design. According to Papanek (1995) a deep concern for and understanding of nature would lead to designs that would help preserve the global environment. To this end, he suggested that designers should ask themselves the following questions:

> Will the design significantly aid the sustainability of the environment?
> Can it make life easier for some group that has been marginalised by society?
> Can it ease pain?
> Will it help those who are poor, disenfranchised or suffering?
> Will it save energy or, better still, help to regain renewable energies?
> Can it save irreplaceable resources?

Papanek brought priority on minority user groups, ecological concerns and waste of resources. He (1991) suggested that we all belong to minorities, each with own special needs. If designers combine all these special needs, they will have designed for the majority after all.

The understanding of *principles in design* as Mayall (1979) suggests, were issued on concerns on how the design process should be carried out in order to obtain a responsible design output:

1. The Principle of Totality
All design requirements are always interrelated and must be treated as such, throughout a design task.
2.The Principle of Time
The features and characteristics of all products change with time.
3.The Principle of Value
The characteristics of all products have different relative values depending upon the different circumstances and times in which they may be used.
4.The Principle of Resources
The design, manufacture and life of all products and systems depend upon the materials, tools and skills that are employed.
5.The Principle of Synthesis
Features of a product must continue to satisfy the characteristics we expect it to possess for as long as we wish, bearing in mind the resources available to make it and use it.

6. The Principle of Iteration

Design requires processes of evaluation that begin with the first intentions to explore the need for a product or system. These processes continue throughout all subsequent design and development stages to the user himself, whose reactions will often cause the iterative process to continue with a new product or system.

7. The Principle of Change

Design is a process of change, an activity undertaken not only to meet changing circumstances, but also to bring about changes to these circumstances by the nature of the products it creates.

8. The Principle of Relationships

Design work cannot be undertaken effectively without establishing working relationships with all those activities concerned with the conception, manufacture and marketing of products and, importantly, with the prospective user.

9. The Principle of Competence

Design competence is the ability to create a synthesis of features that achieves all desired characteristics in terms of their required life and relative value, using available or specified materials, tools and skills, and to transmit effective information about this synthesis to those who will turn it into products or systems.

10. The Principle of Service

Design must satisfy everybody and not just those for whom its products are directly intended.

Similar are the principles offered by the Braun Design Department, determined to bring a difference to the understanding of design, offering long-lasting, purposeful and easy to use products, with honest use of materials and design features. *Braun Design Department's Philosophy* is as follows (Rams, 1998: 41):

Good design means innovation: The opportunities offered by modern technology are far from being exhausted.

Good design means usefulness: Good design maximises the functional practicality of products for specific purposes.

Good design means aesthetic design: The aesthetics of a product is an intrinsic part of its function and utility.

Good design explains a product and its function: By showing the structure of a product in a logical way. Letting the product speak for itself, may in some instances eliminate the need for confusing use instructions.

Good design means honesty: Design must not be used to make a product appear more innovative, more effective and more expensive than it really is.

Good design means durability: It is time to reject the attitudes of the throwaway society. Our natural resources are not unlimited. There is no justification for short-lived trivial products.

Good design means consistency down to the last detail: Superficiality and inaccuracy reveal lack of respect towards products and users.

Good design means respect for the environment: Designers must contribute to the conservation of natural resources. And visual pollution is just as detrimental as physical pollution.

Good design means as little design as possible: Back to purism and simplicity.

Good design is unobtrusive: Products should be as neutral and reserved as possible, leaving room for the users' self-expression (Rams, 1998: 41).

Although acts towards socially responsible design seldom find the support they require in the political and economic sense, they have proven useful in at least its encouragement, drawing attention to how it could be achieved, and to its implications on society. As suggested by Whiteley (1998), the understanding of responsible design, particularly with social consideration, evolves around *socially useful design*, *appropriate technology*, *cultural suitability*, *ecological concerns* in terms of *environmental damage*, *pollution control* and *waste of resources*, and *fair* *and safe labour conditions.* A crucial point is the user, not the consumer, for which the design product is developed. Many users do not achieve the improvements that products may bring to their lives; for many, these products are not available, not accessible, or not achievable, or the products that may improve their lives are not yet designed and produced.

Margolin (1997) believes that if designers wish to increase their influence in the betterment of this world, they have to understand the contents of the *product milieu* - the array of objects, activities, services and environment that fill the world - and how they are incorporated into the users' activities. This, he believes, is achieved through the exploration and study of the interactive relation between the individual and collective activities of the users, and the ways in which new products influence, and are influenced by this process. As Norman (2000) points out, designers cannot consider a design process that does not involve the user group, and is based only on the insights and wishful thinking of the designer.

> 'There is a big difference between the expertise required to be a designer and that required to be a user. In their work, designers often become expert with the device they are designing. Users are often expert at the task they are trying to perform with the device (Norman, 2000: 156)'.

Based on these discussions on the concerns on socially responsible design, the idea of designing a product for a specific user group, that will improve the quality of life and that will be an accessible product, has been chosen as the main theme of this thesis work. It is hoped that, by basing the design process on methodological grounds common to designers and engineers related to design thinking and business environments while evolving this product, the resulting output may reach to serve its minority target group; and also that the design process model employed, may contribute to the generation of further ideas with similar concerns.

1.2. AIM OF THE THESIS AND THE HYPOTHESIS

The aim of the thesis is to devise a design process model to be offered as a structural basis for the development of products that particularly require the designer to know the user group closely, and interact with, throughout the design process, towards developing a product of a totally novel concept that may contribute towards the betterment of any user situation that requires the designer's attention.

The hypothesis is that, *due to the social, economic and ecologic responsibilities that it carries, design is a group of activities that needs to be conducted within a guided process to obtain a product that will best suit the system into which it will be integrated.* In this case, the system is an integrated society that no longer imposes handicaps upon its members with impairments, but aims at a total culture of living, with the difficulties imposed eliminated, in environmental, social and political terms.

1.3. THE SELECTION OF THE PRODUCT TO BE DESIGNED

Design contributes to the social system with the culture, values, and understanding of living it can create and provide, through the products it offers to the built environment. It must be considered that, although today societies with capital interests mainly dwell on the idea of profit through businesses that require the services of design, designers are not responsible only towards their employers or clients, but to the society as a whole. Designers must recognise the power they possess in the shaping of the world and responsibly use that powerful tool, in the betterment of the world.

At a time when persons with disabilities are more integrated within contemporary society, whether the created culture of living and its accordingly built world can be adapted or partly rebuilt to the needs of persons with physical and sensory impairments, should be a current issue that deserves more attention. Handicaps derive from a person's relationship with the environment, a relationship which can be improved if it is modified and rearranged to better suit the person's needs and abilities. For instance, we live in a world created and built for people who can see, by those who can see, perhaps thus making life difficult for persons who do not have visual access to the world, causing an emphasis on the disability of visual impairment as a handicap by limiting their access to the world in other ways as well.

According to Oliver's (1996: 32) social model, 'it is not individual limitations of whatever kind, which are the cause of the problem but society's failure to provide appropriate services and adequately ensure that the needs of disabled people are fully taken into account in its social organisation.' Impairment, according to Oliver, is a description of the physical body, whereas disability has nothing to do with the body, but is something that imposes restrictions on the impairments, on the society's part, causing the exclusion of a group of people from full participation in society. Discrimination is thus institutionalised.

Handicaps may also result from or be reduced by the way a child with impairments is raised, educated and prepared for this world. A young child's body is a source of contact with the world. The child may need to be guided in organising this contact and relating his/her body to the world, particularly if the child has certain physical, cognitive or sensory impairments. Depending on the nature of impairment, the child may require special education and rehabilitation in certain areas of development, to be able to understand his/her place in this world and how to relate and communicate. Contemporary social approaches in child education have changed: education can be modified and restructured according to the needs and abilities of a single child. Play intervention is one method particularly applied in cases of children with blindness, and searches for ways to communicate with a blind child by using toys. With the recognition of the importance of toys for a child's physical, cognitive, emotional, social and moral development, toy design and production, and its impact on education of also children with special needs, have come to the fore. The toy becomes the inanimate object through which a child achieves interaction with the immediate world. Thus toys play a major role in play intervention; they are the objects of interest, sources of stimuli and medium of activity. Through a child's interaction with toys, his/her handicaps can be assessed and the child's education and rehabilitation can be modified to suit his/her needs. As tools of such nature, toys may contribute to the improvement of situations of a disabled child, and reduce the probability of the child growing in a world where he/she will remain highly handicapped. The product to be designed through the design process studied in the thesis will be a toy.

Children with blindness and visual impairment is selected as the user group of the product to be developed. *Pre-school age* is a vital period for these children, who may have limited access to and interest in objects due to the nature of their impairments, in physical, cognitive and socio-emotional terms. It is also an important period when they prepare to receive structured education in schools. Therefore, the toy to be designed will be a *pre-school toy with educational objectives.*

In simple terms, blindness can mean having no vision at all, including no light perception; or severe visual impairment, where the person can either perceive light, or has some residual vision enabling the perception of motion[1]. Sight is the degree of light taken into the eye, it is functional. Vision is what the person takes from the sight, it is assessed on a cognitive level. It is generally assumed that being blind means total darkness but there are different levels of blindness. Any person whose vision in the better eye cannot be corrected with glasses to more than 20/200 is considered legally blind in most countries. Different cases described as having 20/200 visual acuity may function differently depending on the eye condition and kind of residual vision that the persons have (Scott *et al.*, 1977).

According to the registered data, the RNIB estimates that there are in the UK, approximately 10,000 children aged 3 to 19 who are visually impaired. Statistical studies show that there is an increase in the population of visually impaired children since the 1980s (Uslan, 1983; cited in Pogrund *et al.*, 1992). This has been explained as being due to increased survival rate among premature infants, with the technological advances in neonatal care, and the rise in the number of early teenage pregnancies, which may give way to premature birth with abnormalities, or, late pregnancy, which may result with children being born with Down's syndrome, which can be accompanied by blindness. Parents using illicit drugs may also cause children to be born with multiple disabilities including sensory impairments. The infant may be born with a defect or disease affecting the development of the eye. Such conditions are called congenital eye conditions. Visual impairment can also be acquired as a result of traumas, infections or illness.

[1] The RNIB (Royal National Institute for the Blind) Survey of 1992 describes the defining levels of visual impairment as follows:
Level 0 – Cannot tell by the light where the windows are.
Level 1 – Cannot see well enough to recognise someone he/she knows close to his/her face.
Level 2 – Cannot see well enough to recognise someone he/she knows across a room.
Level 3 – Cannot see well enough to recognise someone he/she knows across a road.
Level 4 – Can see well enough to recognise someone he/she knows across a road.

A child develops through playful behaviour, which widely depends on the child's physical and cognitive abilities. The stages of play of the child also reflect his/her stages of development. Being born with vision contributes to the child's willingness to interact with the world through play. For a child with no vision, playing will not be easy, and as a consequence the child may be delayed in physical, cognitive, social and emotional development.

To repeat, the design task has been selected as a toy through which blind and visually impaired pre-school children can be initiated into playful interaction with their environment, and eventually into further stages of learning.

1.4. STRATEGY TO BE FOLLOWED AND THE STRUCTURE OF THE THESIS

The thesis will accommodate the devising and application of a design process methodology, towards the development of a particular product for a specific user group. The model will be such that, it ensures the identification of a particular problem encountered by the user group through their interaction with objects as design products. It will aim at determining a totally novel concept, and not a redesign, towards contributing to this interaction between the user group and design products. Through the application of the model, the objectives towards the product will be determined.

To achieve its aim, the thesis will embody the following strategy: design methods and models will be investigated as to their procedures, techniques, aims, reasons for selection and objectives in their application. From this investigation, an interpretation of the design process will be structured, which may involve the methods and models found in relevance to the design problem in hand, and to insights to be derived, on how such a problem should be handled. Following this, the design process structure offered will be applied for the selected design task of *designing a toy with educational objectives for blind and visually impaired pre-school children*. Finally, the outcome of the process and the insights gained during its application will be evaluated so as to assess the stengths and shortcomings of the proposed structure, the contribution it brings to design methodology, and the implications of the design product as an outcome of this process, on the user group.

The thesis is formed of 8 chapters. Following *Chapter 1. Introduction*, is *Chapter 2. Discussions on Design and Design Methods*, which is a brief review on the nature of design as a creative activity, as a process, and as an outcome of this process. It will be argued that design needs to be organised in a guided framework, that integrates creative activity and technological progress within the process. The argument of the pioneers of early design methods in the 1960s was that design methods were necessary in systematising the creative activity in design, assisting designers in problem solving, creative thinking and decision making, and simultaneously making design scientifically respectable. Design methodology emerged as a discipline, studying the acts of the designers during the design process; methods devised were classified, and further methods were generated as the need arose. *Chapter 2.*, will discuss examples of early methods, that particularly made their mark on design thinking in their era.

Chapter 3. Design Methods as Discussed Today, discusses with examples, the design methods that followed. As will be observed, with the pace in tehcnological progress, and business concerns in profit and saving of time, the methods became more like techniques to rapidly generate random ideas, and systematically eliminate them towards a final design decision. It will be argued that such a fragmented, and random approach to the design process may offput designers in the application of methods. All the same, the necessity for a systematic approach remains.

With growing businesses and progress in technology, design has become part of an extensive process of product development, which also integrates issues on management, marketing, production and planning. The design activity in this teamwork, again requires the planning of the design process, this time to obtain the optimum output within a series of carefully constructed acts. *Chapter 4. Employing Design Methodology and Phase Models in the Design Process*, reviews phase models, which are systematic guidelines in organising the design process, with consideration given to keeping the process in integrity, as alternative to selecting and applying design methods into the process, which may cause fragmentation. The models chosen to be discussed in the chapter are examples suggested by designers, and also those from the fields of engineering, as engineering is a major influence on design methodology and phase models. The study of and discussions on the differences of approaches of engineers as scientists, and of designers as performers of a creative act, will help found a common ground that may be formed into a process model, not aimed for profit concerned businesses but towards a common medium of discussion for the future responsible uses of the design process.

In the light of the reviews and discussions in the preceding chapters, *Chapter 5. An Evaluative Discussion of Design as a Discipline*, reviews the nature of design as a discipline in its own rights, and discusses its role in the generation of knowledge. The discussions lead towards an interpretation of design as a process and as an activity, that involves collaboration from diverse disciplines, in order to create design products and generate knowledge related to these products that comply with the needs and interests of the society, having been based on sound knowledge. The user group must be regularly involved in this process, as design products are for users in real-life situations. In their turn, the design products may contribute to the generation of design and other disciplines-related knowledge.

These arguments lead to a reinterpretation of the design process, with the entire activities it is envisaged to bear. A reinterpretation of the process, in *Chapter 6. The Design Process Reinterpreted for the Proposal of a Design Process Model towards a Specific Product for a Specific User Group*, discusses a basic pattern of activities that must take place in the design processes for all design tasks, the essence of activities that produce step-by-step outputs, towards a final design product/output. It will be argued that this *core*, common to all design processes, may be used to build on it, design models of various concerns and integrating diverse activities that may be applied to design tasks of various nature. To illustrate this argument, a *design process model* is built on the *core*, for the particular design task of *designing a toy with educational objectives for blind and visually impaired pre-school children*. The devised model has particular concerns for *problem identification*, *novel concept generation*, and *frequent involvement of the user group throughout the process*.

Chapter 7. Implementation of the Built Model towards Designing and Realisation of a Toy for Blind/Visually Impaired Children, is devoted to the implementation of this design process model. The chapter embodies an intense research on the user group, and toys, towards identifying a problem area related to the blind/visually impaired children to be encountered, the concerns and issues in toy design and play value, and determining the objectives of the educational play material to be developed. A large section deals exclusively with the generation of ideas, that particularly underline the creative activity that design involves, and the systematic accumulation of concerns, ideas and responses from the user group towards the forming of the final concept. Following the design and manufacturing of the working model, the Chapter describes the field testing that took place among samples from the user group, in a playgroup in the Kent area. The insights gained from the study contribute to the reconsiderations of the design decisions made.

Finally, *Chapter 8. Conclusion*, evaluates the design process model, in the light of the review on design methods and models, and of the insights gained during its implementation. It is argued that, the design process core allows the building of design process models that will suit all design tasks, as it offers the essential core activities related to the design process. Also, the role of the designer is not limited only to the carrying out of the creative act of design, but is extended to the organisation and integration of the knowledge, skills and ability of a multidisciplinary nature, to devise own design process model to organise and conduct an individual or a collaborative design process. And finally, the argument is that, the employment of the design process model reflects positively on the outcome as a product responsive to the life system of a particular user group.

2. DISCUSSIONS ON DESIGN AND DESIGN METHODS

Norman Bel Geddes (1893-1952; cited in Lambert, 1993) defines design as dealing exclusively with the organisation and arrangement of form. Forms are ways of arranging and articulating material in space, just as syntax and grammar arrange words into language. When manufactured, form becomes an embodiment or expression of the product. Yet, design cannot simply be considered as the arrangement of forms. Morrison and Twyford (1996) describe design as a creative and disciplined activity based upon bringing together information, knowledge, skills and sensitivities within a working context, as a means to order our surrounding by reshaping materials to suit our needs and purposes that arise at the interface between humankind and raw environment.

Rawson (1987) believes that every designed object falls somewhere along a *spectrum of purposes* between pure function and pure symbolic expression, and that, all design has four aspects: *material*, *process*, *form* and *purpose*. Similarly, Papanek (1991) describes design as a *function complex*, which means that design not only comprises the act of designing, but also involves a combination of other acts with different functions. The six parts of this function complex he describes, are:

Method: Design requires the creative interaction of tools, material and process within a methodical approach.

Use: Design can be used as tool, as communication, as symbol. A design must be able to *tell* whether it works, how it works, where it belongs, when it should be used; its form must be honest to its purpose.

Association: Design products are associated with values related to family and early environment, education, tradition and culture. Their design can be manipulated in order to further enhance those values.

Aesthetics: Design has an aspect playing upon the Gestalt, perception and biosocial givens of humans. As aesthetics is a tool in the expression of the beautiful, the exciting and the meaningful, it may be used in shaping forms, colours and textures, to express the creativity and taste of a culture.

Need: Rather than satisfying evanescent wants and desires, design must address the genuine needs of people, which may be of economic, psychological, spiritual, social, technological and intellectual nature.

Telesis: The telesic content of a design, which is the reflection of the times and conditions that have given rise to it, has to fit in with the general human socio-economical order, for the product to operate efficiently.

'Design has its own purpose, values, measures and procedures' (Owen, 1998: 10). This statement makes design an area of knowledge that in itself has sub-areas which all have specific processes of carrying out the design task. Jones (1966) describes four kinds of design situations:

Environment: Regional plans, buildings, enclosures, etc.

Flow systems: Sets of separate components, which together perform a well-defined function; airlines, administrative systems, supermarkets, etc.

Products (or mechanical systems): Of a single unit of closely integrated parts, which together perform a set of functions. They may be a component in a flow system or in an environment, or may be used independently, such as a window, a tractor, a garment or a pump.

Parts: Single pieces of material from which products are assembled; such as nuts, bolts, tyres or bricks.

Each design situation has its own traditions, values and processes. The product to be designed can be anything from clothing, packaging, furniture, buildings, to electronic appliances to be produced in a single amount or in mass quantity. Industrial design is a specific term in the domain of design, and it is on this that we shall mainly dwell in the scope of this thesis. Archer (1974: 9) defines industrial design as 'the preparation of a prescription for some artefact or system in the light of all the relevant functional/constructional, economic, marketing, ergonomic and aesthetic requirements'. It is the design of a product (an object or part of an object) to be mass produced on an assembly line in industrial facilities supported by intense research, engineering, production processes, strategic and marketing investigations, while giving particular emphasis on aesthetic appeal and ergonomic considerations, to reach a target group, sharing general descriptions.

2.1. DISCUSSION ON THE DESIGN PROCESS

'Design is a goal-directed problem-solving activity', as Archer (1965; cited in Jones, 1980: 3) describes, but 'solving a problem is not always designing', as Shadrin (1992: 1) explains; 'consciously building a device to solve a problem is participation in an act of design'. The design process begins with the determination of a design problem, and the process itself is constituted by acts carried out to find solutions to this design problem. The word problem does not indicate a complication that has to be resolved, but that there is a situation that needs an efficient act to obtain a result in the form of an artefact or a service that satisfies the users in the situation. It is convenient to formulate the situation as a problem, and resolve it systematically in the design process, through investigating possible solutions that will satisfy the situation.

Design problems result from needs and demands, and they are not always easy to define and formulate as they precede a search through an unfamiliar solution space. Pahl and Beitz (1996) suggest that problems are characterised by three components: *an undesirable initial state*, *a desirable goal state*, and *obstacles that prevent transformation from this undesirable state to the desirable goal state, at a particular point of time*. Shadrin (1992) suggests that considering the function of the object to be designed, the designer will have to understand the problem through questions such as: *What does it do? How does it work? Who will use it? Where will it be used?*

The designer will have to face marketing facts and search for answers to the following types of questions: *What competition will this product face? What type of client will the product attract?* Answering these questions will require investigation through formal analysis considering the purpose and function of the design, historical reference such as how it was done before, what skills are needed for the design, with which technology the design will be produced, and how the resulting solution will be evaluated to investigate whether this is the best that one can come up with (Shadrin, 1992). Answers to the problem will be in the many ideas which are generated. While selecting from the generated ideas, their feasibility, the availability of the relevant materials, whether or not the solution is economical, and the time allotted for its realisation, should all be taken into account (Chapman & Peace, 1993).

Designers searching for solutions to a particular design problem exhibit rather stable individual ways of carrying out the design act and organising their design process accordingly (Eisentraut & Günther, 1997). Problems may be complex and uncertain by nature, the conflicts and inconsistencies may have to be resolved during searching for the solution (Cross, 2000) and may require subjective interpretation from the designer's part (Lawson, 2000). As a method, designers may tend to search for potential solutions to further understand the problem, by exposing specific areas of uncertainty related to the problem. Consequently the problem and its solution co-evolve. It is a common practice that the designer represents the generated ideas quickly by making sketches and drawings. Görner (1973; cited in Eisentraut & Günther, 1997) refers to sketches as the *thinking tools* for the designer and elaborates that designers achieve solutions step by step, alternating phases of thinking with sketching.

During thinking and sketching, the designer generates a wide range of ideas to contribute to the development of a concept, which is the design principle for the new product (Baxter, 1996) usually requiring creativity as it aims at bringing innovation to the situation in hand. Innovation in products has been a major pressure in the market the last decade. As Baxter (1996) points out, the average life span of products is shrinking fast, as new technologies (CAD, rapid prototyping, tooling) reduce product development time. The key factor to innovation is creative thinking – searching for totally novel concepts and ideas. Innovative thinking will require the breaking of obstacles such as worries to find the right answer, to follow the rules, trying to be logical and practical, trying to avoid ambiguity, or being reluctant to cross into another area (Shadrin, 1992). Cross (1997) describes a successful creativity act resulting with a novel solution as *the creative leap*, which is a sudden perception of a totally new perspective on a situation, where the designer shifts to a new part of the solution space and finds an appropriate concept. However this does not imply unreservedly free imagination in the decisions and use of the elements. Deciding for innovation is a risky and complex process, as new product development requires careful research, planning, control and selection of systematic methods (Baxter, 1996), and evolves through the skills and knowledge of marketing, engineering and industrial design working together. Creative thinking too, therefore requires a systematic and conscious evaluation of all possibilities.

Having evaluated the generated ideas, the designer has to make critical decisions for selecting from among the alternatives, the design project to be put into realisation. As Gregory (1966) explains, decision making is an imaginative act in which the designer eliminates the intangibles and uncertainties and takes responsibility for the outcome. The decisions made in the initial stages of the process are critical, as the cost of altering or abandoning the process in later stages may be too high. Jones (1966) explains that collecting and assimilating adequate relevant information is vitally important, so that an illuminatory analysis can be made on which to base the decisions. A decision takes place when there is a match between the design and the requirements (Gregory, 1966).

Control is a necessary element in the design and production processes in order to achieve optimal safety, quality, reliability and aesthetic values. According to Mayall (1979) control may be observed over created products through laws, regulations and standards, or control may be based upon removing deviation from a desired object. Other mechanisms of control are testing and evaluation, that take place after the realisation of the product, to help understand the weaknesses or strengths of the realised design project, by using the product in a real life situation among the target group. Testing can be in several categories:

Performance testing: Done to ensure that the product performs its physical requirements. As Chapman and Peace (1993) explain, testing may be functional, to see the way the product works. It may involve repeated tests, checking up the solution's reliability by experiment, or by simulation in cases where tests may result in accidents.

Safety testing: Done to ensure that the product verifies safety regulations.

Field testing: Done to assess the product among a selected sample of users before it is distributed into the market, for reliability, performance, and user reaction.

Evaluation covers a broader span of time. It may take place during each step of the design process, evaluating the decisions by designers, engineers and the managing group to determine the next step to be taken, or if modifications should be made before continuing on. It may involve evaluation of the generated alternative ideas to select one from among them. It may also take place after the testing of a finalised and manufactured product to determine whether it has achieved its aim at an optimal level. Evaluation continues after a product is distributed into the market where it meets its target users in real life situations. Ideally, feedback returns to the producer who is informed of user interest, the product's performance, whether it has fulfilled its purpose, and completed the predetermined life span. It helps the producer to decide whether the product line will continue, which changes should be made, and how it can be adapted to the continually evolving situations it is used in. The whole design and production process may also be evaluated as to the strengths and weaknesses in the strategies, activites and decisions involved.

As discussed above, the design process follows a general route made up of stages that have to be fulfilled. As the performance of designed products reflect upon the society, decision making errors during the design process cannot be tolerated, even in the name of creativity or innovation. Design methods have evolved in order that the various activities in the design process are followed through in an organised framework, minimising the risk of neglecting a step in the process, or errors of decision.

2.2. THE EMERGENCE OF EARLY DESIGN METHODS

'Designing is to initiate change in man-made things' (Jones, 1980: 4).

When Jones suggested this definition of design, what he meant was that, after the realisation of a design, whether it be a product, a building, or a system, and whatever the success of it, the world would not be the same anymore. This definition has been criticised by design thinkers and practitioners such as Lawson (2000) for being too abstract and highly general; however Jones' implication is that, designers must be able to predict the ultimate effects that their design will have on the situations that the design products are brought into, as well as specifying actions that are needed to bring these effects about. As Jones further explains, the objectives of designing become more and more concerned with the changes that the product will bring upon the society, and with how the society will have to adapt itself to benefit from the product. If design products are so influential on the society, the process with which the products are evolved, certainly needs to be not left to chance, and must be well methodised. This role and responsibility of design, particularly industrial design, is relatively new and sensed more strongly within the consumerist society of today. While the fields of design such as architecture, interior design, fashion or graphics have a history and tradition of their own, industrial design is considered to be a new profession (although the designing of products particularly craft products is an ancient one; as Papanek (1991: 29) states: ' "In the beginning was design", obviously, but not industrial design'). The effects of its outcomes have strongly reflected on the societies since only a few decades, and its methods of mass production have been greatly influential in the emergence of design methods. At this point, a brief history of industrial design and its role in the evolvement of design methods may give an insight into the earlier attempts at methodising the design process.

The seeds of the profession were implanted in the industrial revolution, which triggered a fast pace in discovering new materials, new uses for these materials, and mass-production. This changed the lives of industrialised societies, giving them the power to dominate resources with which to build, produce and shape the world. According to Lawson (2000), change was so fast that craftsmen could not keep up, and did not have the time to adapt. Changes in both the materials and technologies available became too rapid for the craftsmen's evolutionary process to cope. The design process that had taken years for craftsmen to evolve a product with, into its final stage, had to become so rapid that it was no longer the careful and wilful planning but rather a response to changes in the wider social and cultural context. The industrial society required novel products that became part of the system at this new life pace, shaping and re-adapting the system itself in time. Product design started diverging from the crafts, and the profession of industrial design emerged: products composing the industrial lifestyle became standardised and were manufactured in industrial facilities in mass quantity, rather than as customer-fit and one-off products, made in the workshops of craftsmen. The diversion of crafts and industrial design made the design of products a technological discipline of its own. The products referred to, were in general components and parts of industrial systems, or the systems themselves. But, industrial designers were also excited by this idea of considering design a technological activity and were willing to apply design methods used by engineers, to their own design processes.

As early as 1940, Harold Van Doren (cited in Tovey, 1997: 8) defined industrial design as: 'The practice of analysing, creating and developing products for mass manufacture. Its goal is to achieve forms which are assured of acceptance before extensive capital investment has been made, and which can be manufactured at a price permitting wide distribution and reasonable profits'. With such a definition of industrial design, it may be possible to assume that the role of the profession and its impact on the economy and culture of the society were already recognised before World War II. Again in that era, the fast advance of technology gave engineers the confidence to argue whether engineering design could be considered as a field of science. However, the Second World War was when the benefits and services of design were particularly discovered and made use of. There was need for the careful designing of products and selection of materials due to shortages and economic restrictions. It was then that the notion of *ergonomics* was introduced; human factors data, based on white males between the ages of 18 and 25, was used in the design of war supplies (Papanek, 1991). Henceforth, the study of the physical and psychological factors have been used to improve the design of products for human use. Systematic approaches in the design process were developed through *operational research* used in collaboration with teams of scientists, engineers and others in solving wartime problems (Archer, 1999). Such systematic methods were necessary also to be able to assess situations into which a novel system or component was to be integrated, to produce an optimum solution to certain problems that these situations brought, on time, and within economic limitations. Following such systematic methods made design acceptable as a scientifically sound activity and helped in the foundation of the initial concepts of *design research* as a discipline.

2.3. DISCUSSIONS OF THE NEED FOR DESIGN METHODS

Jones (1980) explains that before design methods emerged, designing was what was done to produce drawings that were required to be presented to the client to be manufactured or built. The methods used today seem to be mainly concerned with the processes that precede and follow the actual drawing stage, and more related with procedures on how to support the thinking on the design decisions, aiming to offer a variety of alternatives and selecting the most suitable alternative as solution for the situation in hand. Jones (1980) describes design methods in three categories; *traditional methods*, *design-by-drawing*, and the current *design-by-methods*.

Traditional Methods are based on design by trial-and-error, evolving artefacts through centuries of experience and hard work of craftsmen. Traditional methods have remained inadequate in the sense that they produced tentative solutions as the result of a quick exploration of the situations in hand into which the solution has to fit. With *design-by-drawing*, scale drawings are made through a process of thinking. This has brought the advantage of drawing before making, and being able to correct certain decisions. Another advantage is the possibility of producing large-scale projects beyond the scope of a single craftsman to manufacture, such as of ships and buildings. This has made it possible for different parts of the design to be manufactured by division of labour, increasing production rate and leading to the specification of standard dimensions in certain fields of production. On the other hand, it may bring the probability of loss of quality in manufactured goods. Another weakness Jones describes is that, thinking on paper belongs to one mind only, and does not share thoughts of many, in the process of critical decision making. Besides, design-by-drawing has remained too slow and simple for the growing complexity and fast pace of changes in the man-made world.

New methods had to be developed for planning the process of design, and designing. All professions started planning their activities on an industrial basis where man-machine systems have been developed (Jones, 1980), and the interaction of humans and products have had to be compatible with these systems. The designer or engineer had to be aware of the current information related to these systems into which artefacts or services were developed, and to predict the future into which they would be integrated. Just as Lawson (2000) argues that the design process had to adapt as a response to rapid changes in the wider social and cultural context in which design is practised, Jones (1980: 31) similarly suggests that new methods were devised because 'humans failed to design for conditions brought about by the products of designing'. While traditional design methods operated on the levels of *components* and *products*, the design process today has to include system design into which human-made products are brought in. New methods have had to extend to include the planning of *systems* (relationships between products) and then of *community* into which artefacts are to be integrated. The community level indicates the political and social aspects of human behaviour, and requires that, the power of political action and organisational planning should be combined with the flexibility and foresight of product design (Jones, 1980).

Another point made on the necessity for *design-by-methods* has been the need to involve all the people related to and affected by designing: the sponsors or clients, the designer or the design team, suppliers, producers, distributors, purchasers, users, system operators, and the society. Communication between particularly the sponsors, the design team and the manufacturers assures that the design situation is well understood. The sponsor has to be precise in explaining what is needed and be open-minded to the offered solution in case it may not look as had been envisaged, although fulfilling the requirements. The design team may be composed of persons of different interests and professions, with collaborative skills. The purchasers and the users of a product may not be the same. The purchasers, also sensitive to patterns, colours, style, and shape, will be concerned with the recognised meaning and social significance of the product. The users on the other hand, may take long to adapt to new situations, due to physiological or psychological factors. The design situation may require that user behaviour is observed, and moral and economic assessments of the costs and benefits of adaptation made. The persons involved in the design process may have different reactions to innovation and change. Jones (1980) particularly stresses the fact that the design process is no longer limited with the designing and manufacturing of an artefact, but that it continues even after the product is purchased and is in use. The process is thus not a mere technical procedure that can be applied to different situations, but is closely evolved around human behaviour such as decision making, problem-solving, use of imaginative and collaborative skills and particularly efficient communication between all persons involved.

The complexity of the design process is not only limited to such human skills and need of collaboration, but also lies in the necessity of research that has to precede certain decisions, which is still another point for the call for *design-by-methods*, that will incorporate research at various stages of design. New design problems can no longer work only on products level, but have to include search within systems level. The results of research will have to be accessible to other design teams dealing with similar design situations, to which the next design team will add their own findings, ideas and ways of approach, to pass on to others. As Jones (1980: 45) points out, through *design-by-methods*, the act of designing has been made more manageable particularly at the systems level, by attempts of making the private thinking of the designer public, or 'externalising the design process'.

2.4. EARLY DESIGN METHODS AS TECHNIQUES AND PROCEDURES

Early design methods offered patterns of routes to be followed, suggesting that design problems could be dealt with, with similar processes, whatever the context of the problem may be. The starting point of all these methods was the *Scientific Method*, devised by scientists for problem-solving in scientific research, and used widely for investigating what exists in nature, involving the generation and testing of models of parts or the whole of the universe (Jones, 1980). It did not take long though, to recognise the shortcomings of this approach to the design process which considered design to be a science. Science, it was argued, dealt with what exists in nature, it is *descriptive*. Design on the other hand, is a search for what should exist, therefore it is *prescriptive*. Regarding this distinction, from the *Scientific Method* was derived the *Design Method* by McCrory. Although devised for engineers, it became a popular source of investigation as to its nature, application and outcome, for designers as well. As Gregory (1966) explains, while the *Scientific Method* was an analytical way of problem-solving, the *Design Method* was a constructive way.

It can be argued that engineers employing design methods tended to be concerned strictly with technical problems. McCrory's (1966: 11) definition as: 'Design is considered as the process of selectively applying the total spectrum of science and technology to the attainment of an end result which serves a valuable purpose', points that design was seen as a functional process concerned mainly with the importance given to the functioning of the outcome. For design thinkers of this vein, design is a segment of engineering which devises and develops new things, and it must follow a closely evaluated path: 'starting from a well-considered if not urgent need statement to a functioning achievement'. According to Gregory (1966), the interest in systematic procedures in design came from the fact that, the techniques employed by skilled designers could be identified and studied in order to propose organised design techniques to other designers or those in training to become designers. Yet, Gregory observed that systematic procedures could not in themselves produce outstanding design. While they may offer the possibility of raising the general competence of the designer in tackling an average design problem with the checklists and steps suggested, there is the intrinsic danger of routine behaviour.

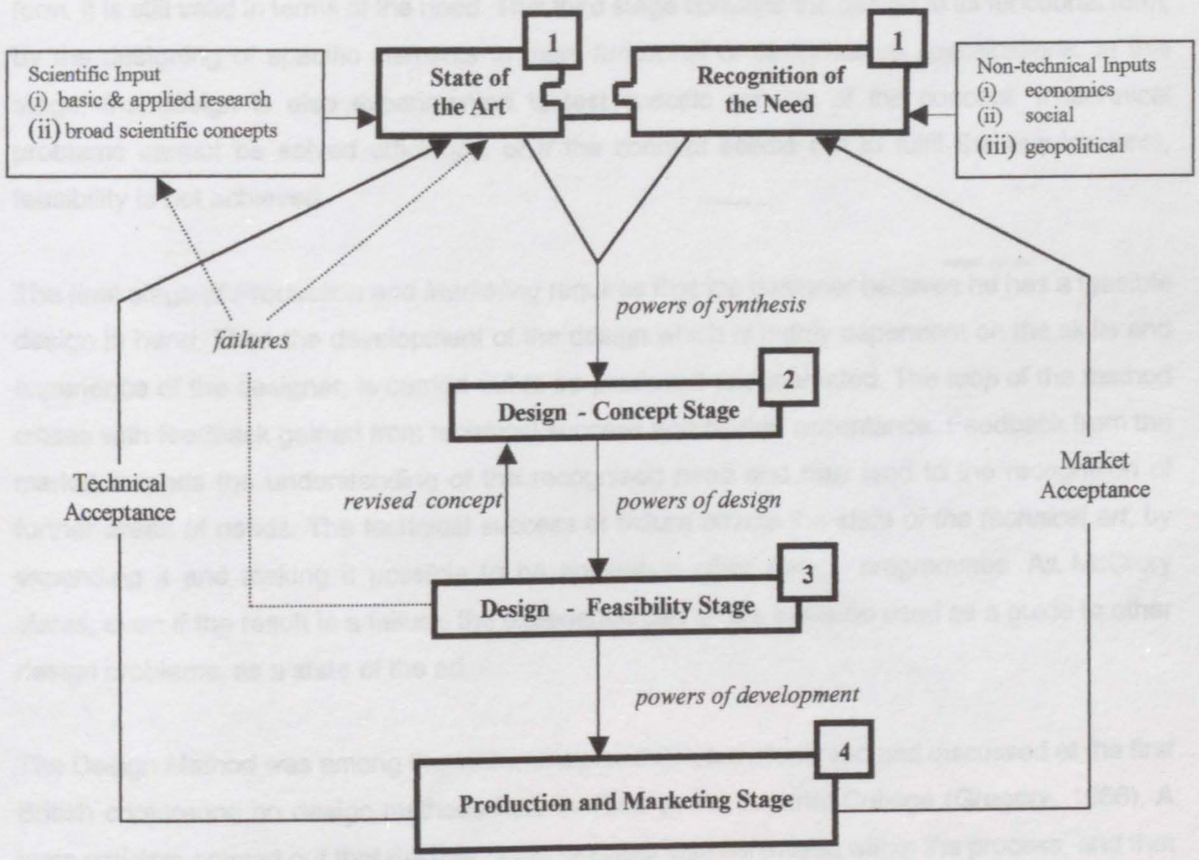


Figure 2.4.1. The Design Method by McCrory (1966: 12).

McCrory's *Design Method* (*Figure 2.4.1.*) is a framework expressed in a sequence of actions yielding into a closed loop in order to establish check-points from which to evaluate the progress of the process. McCrory (1966) explains that, unlike scientific research, design is motivated by need, rather than by curiosity. Therefore in the initial stage, besides knowledge of *the state of the technical art*, the method requires *recognition of a need* which makes an investment of effort and funds worth. The definition of the *need* is of particular importance as the following stages in the method are planned and carried out accordingly, and is highly related to marketing input. *State of the art* in this case is the material capabilities, phenomena understanding and previous design experience. As the main purpose of the method is to produce something which is really useful in satisfying the recognised need, the designer must not aim for small improvements but for serious design progress.

The second stage, the *Design Concept* is achieved when the designer's synthesis ability matches the recognised need and the technical capability represented by the *state of the art*. This synthesis may take place by initially analysing the need in considerable depth, then by spatially visualising systems as advantageous combinations. Another path McCrory suggests is to explore analytically, the area of design interest, and manipulating generalised mathematical expressions in order to derive unique design approaches which may not be apparent from spatial visualisation. Once the design concept is attained, *feasibility* is assessed by checking whether all of the functions of the system can be worked out, and whether, when the design is in its detailed form, it is still valid in terms of the need. This third stage converts the design to its functional form, by the designing of specific elements to meet *functional* or *performance specifications*. In this stage, the design is also experimented to test specific aspects of the concept. If technical problems cannot be solved efficiently, or if the concept seems not to fulfil the requirements, feasibility is not achieved.

The final stage of *Production and Marketing* requires that the designer believes he has a feasible design in hand. Then the development of the design which is highly dependent on the skills and experience of the designer, is carried out to be produced and marketed. The loop of the method closes with feedback gained from technical success and market acceptance. Feedback from the market extends the understanding of the recognised need and may lead to the recognition of further areas of needs. The technical success or failure affects the *state of the technical art*, by expanding it and making it possible to be applied in other design programmes. As McCrory states, even if the result is a failure, the experience can all the same be used as a guide to other design problems, as a state of the art.

The Design Method was among the methodologies that were presented and discussed at the first British conference on design methods held in 1962 at the Imperial College (Gregory, 1966). A main criticism pointed out that the role of the designer was minimised within the process, and that the use of methods could restrict the designer from bringing forth his individuality, by lessening his contribution of imagination and intuition to back up the design method. A counter view offered by Eder (1966) explained that the designer's responsibility covered the whole process from conception to production and even the whole life of the product during service. Eder defined industrial design within the 'artistic functional field' thus differentiating from among pure artistic, functional artistic and engineering fields, where design methods show similarities but diverge in the use of theories, production technologies and working constraints. Eder found worth discussing the following six design methodologies: *Experience*; *Modification and Running Re-design*; *Check-lists*; *Design Trees*; *The System Search Method* and *The Fully Systematic Method*.

The use of *experience* as a design method involves techniques such as *empiricism*, and particularly *trial-and error*. Experience is highly related to how the designer is trained, who he has collaborated with, and how he has been able to store information related to this experience in his mind. Although at times this method may be reliable such as the use of trial-and-error, a major disadvantage may be that the design process is rarely documented during the experience. *Modification* involves improvements in an existing product, studying the present product in depth so that the alterations do not aggravate the condition of the product and its relation with the system it belongs to; and rarely results in innovations. *Check-lists* set up a list of influencing factors for each step of the design process to remember, complete, put thoughts on paper, watch the progress, evaluate the work and document. It also requires that the designer notes down reasons for the decisions he has taken, not only to document but also as a reference to other persons who will use the information.

Trees are used to break down a problem into branches that can be broken down again to find a solution to each branch of sub-problem. By combining the simple solutions to each branch, a number of alternative and well-thought out solutions to the problem can be obtained. Apart from the branching *Game Tree* (*Figure 2.4.2.*), another method used is the *Design Tree* (*Figure 2.4.3.*), where the vertical line indicates a problem, and a branching line indicates a solution. Each solution and problem are given letters and numbers in order to pick up combinations of solutions such as *a2a1b1*. A short statement of each problem and solution is also given on the design tree. As the problems are solved step-by-step, and no further problems appear, the lines leading to the solutions are shown in bold. This technique has been offered to obtain novel design solutions.

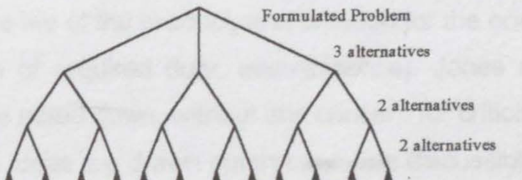


Figure 2.4.2. Game Tree (Figure from Eder, 1966: 25).

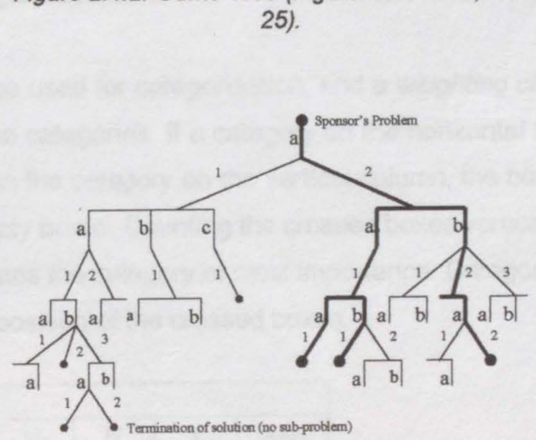


Figure 2.4.3. Design Tree (Figure from Eder, 1966:26).

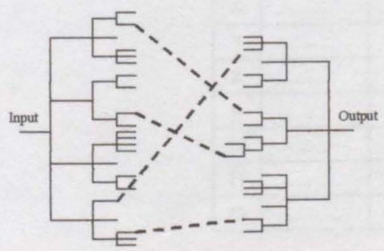


Figure 2.4.4. System Search Tree (Figure from Eder, 1966: 30).

The *System Search* technique was offered for situations where the elements or the technology for their attainment are available; to obtain required system properties by connecting the available elements in a suitable way, to bridge the gap between inputs and outputs (*Figure 2.4.4.*). The process begins by preparing a *throughput flow* *diagram* (*TFD*), where each block represents a function that does not have a related hardware, in other words, a *system element*. Each block has an *input* and an *output*. The blocks are then matched, transformed, split, augmented, etc., until the output of one element is related to the input of another, and each new block has an available system element of hardware. The TFD diagram is thus transformed into the *block schematic diagram* (*BSD*). The system represented in the diagram is then checked through calculations and experiments, and modified according to the performance to be attained and to cost-related constraints.

The *Fully Systematic Method*, reported by Jones and Thornley (cited in Eder, 1966) breaks down the stages of the design process to be solved by various data processing techniques, in order to minimise backward overlap. This method was found useful particularly for teamwork on design problems of large scale. In the *analysis* (or *preparation*, as Eder suggests) stage, the designers set up a list of relevant factors, or statements, such as considerations on the basic functions to be fulfilled, the capability and limitations of the production organisation, the customer, the user, the environment, regulations and standards, the entire life of the product, and criterion for the end of the product's life (failure of service, completion of required duty, obsolescence). Jones and Thornley particularly recommend that all ideas are noted down, without any concern for criticism. A technique they suggest is *brainstorming*, where ideas are drawn out through free discussion of a group. As there will probably be a large number of factors, they are categorised and numbered in order of appearance and supported with a single statement.

A *factor classification chart* (*Figure 2.4.5.*) may be used for categorisation, and a *weighting chart* (*Figure 2.4.6.*) to determine the importance of the categories. If a category on the horizontal row is considered by the team as more important than the category on the vertical column, the box is crossed, and a reference dot is placed in the empty boxes. Counting the crossed boxes vertically, the column with the lowest sum of crosses indicates the category of most importance. Categories with equal sums are evaluated according to the position of the crossed boxes.

	Sponsor's Problem						
No	Factor Content	I	II	III	IV	V	Design File
1	....	X					∘
2	....	X					∘
3	....		X				∘
4	....			X			∘
5	....		X			X	∘
6	....			X			∘
7	....				X		∘
8	....				X		∘
9	....					X	∘
10	....				X		∘
11	....			X			∘
12	....		X			X	∘

Figure 2.4.5. Factor Classification Chart (Figure adapted from Eder, 1966: 27).

Category		I	II	III	IV	V	VI	VII	VIII	Order
....	I		×	.	.	×	×	.	×	4
....	II	.		.	.	×	×	×	×	5
....	III	×	×		×	×	×	×	×	1
....	IV	×	×	.		×	×	.	×	3
....	V	.	.	.	.		×	.	.	7
....	VI	.	.	.	.	.		.	.	8
....	VII	×	.	.	×	×	×		×	2
....	VIII	.	.	.	.	×	×	.		6
	Sum	3	3	0	2	6	7	2	5	

Figure 2.4.6. Category Weighting Chart (Figure adapted from Eder, 1966: 27).

How each category influences others is investigated with an *interaction matrix (Figure 2.4.7.)* or *interaction nets* (*Figure 2.4.8.*), to question and investigate the nature or lack of interaction between categories to reveal further factors that may have been overlooked, and to reveal weak and strong connections between the factors. The interactions are determined to be transformed into *performance specifications*; with each interaction determining at least one *performance specification* (*p-spec*). This is not a design requirement, but a defined performance; therefore it is not a solution, but a processed form of the sponsor's needs. It is particularly important that *p-specs* do not suggest solutions but contribute to the problem definition as they will be presented to the sponsor for his approval or modification before going on to the next stage. The list may also be used as a list of criteria to assess the final solution.

	I	II	III	IV	V	VI	VII
VII I	•						•
VII	•	•		•			
VI		•			•		
V							
IV	•		•				
III	•						
II							

Figure 2.4.7 Interaction Matrix (Figure adapted from Eder, 1966: 28).

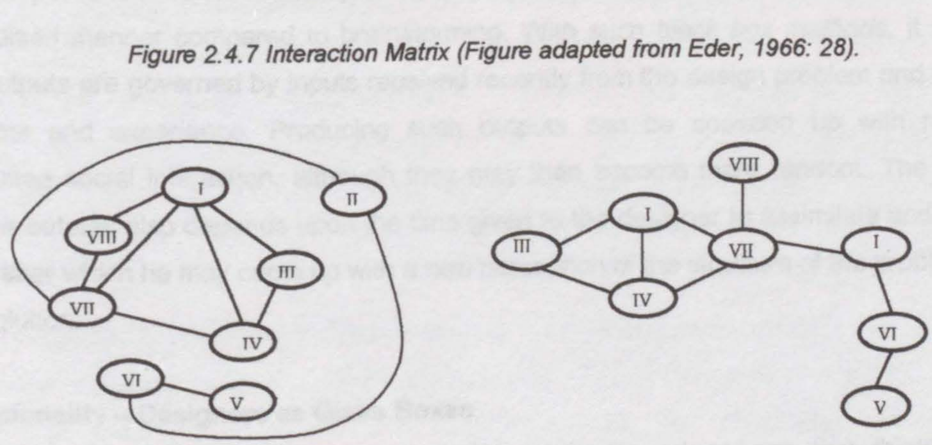


Figure 2.4.8. Interaction Nets defining the same interaction in different ways (Figure from Eder, 1966: 28).

Each p-spec is solved independently in the *conception* (or *incubation* as Eder suggests) stage in words and sketches. All possible solutions are considered and listed in a *morphological chart* (a solution chart) as suggested by Norris (1963; cited in Eder, 1966). The process can also be supported by techniques suggested by Gregory (1963; cited in Eder, 1966) and Jones (1963; cited in Eder, 1966), such as playing with words and concepts, studying past solutions, looking up the design file that was started at the beginning of the analysis stage, etc. Any p-spec or partial solution that requires further research, consultation of a specialist, or testing, is dealt with.

The partial solutions are then assessed for compatibility with each other, by using the interaction matrix, or according to the order of importance, with a game tree where the branches grow only when solutions are compatible. The resulting number of alternative solutions are represented in drawings. The solution most suitable to the requirements may be selected by using the list of criteria; by simulation with models, drawings, experiments; by submitting the solutions to the evaluation of an independent authority; or by trying to eliminate or combine parts or functions of the solutions. The final design solution is communicated to the production organisation with layout drawings and models, and a written report that explains all assumptions relevant to the design, such as a description of the function under all possible conditions, control and maintenance.

2.5. EARLY DESIGN METHODS AS STRATEGIES

Jones (1980) reviews the early design methods from three points of view.

1. Creativity – Designers as Black Boxes

These methods assume that the most important stage of the design process takes place in the designer's head, and through creative skills, the designer is able to produce output without being able to explain how. This category encompasses most of the traditional approaches to design, discussed in Section 2.3.. Theorists of creativity have devised methods to stimulate creativity in the design process such as *brainstorming* where a group of persons come together in a relaxed social situation to produce ideas without being limited by criticism; and *synectics*, where again a group of persons produce ideas by using analogies to re-pattern inputs into outputs in a more methodised manner compared to brainstorming. With such *black box methods*, it is assumed that, outputs are governed by inputs received recently from the design problem and by previous problems and experience. Producing such outputs can be speeded up with relaxed and uninhibited social interaction, although they may then become more random. The capacity to produce outputs also depends upon the time given to the designer to assimilate and manipulate ideas, after which he may come up with a new perception of the structure of the problem towards its resolution.

2. Rationality – Designers as Glass Boxes

Rational methods form the majority of design methods and assume that thinking can be systematically explained. They operate on the information supplied to the designer and follow a planned sequence of steps and cycles of *analysis*, *synthesis* and *evaluation* until the designer believes he has achieved the best possible solution. Objectives, variables and criteria, and the strategy to be followed are fixed in advance. Which methods have to be selected as strategy for the design process, how they can be handled and applied, depend on the nature of the design problem.

The design problem should be investigated as to whether it can be split into sub-problems that can be solved in series or in parallel. Particularly in large-scale problems, to split the work between members of the design team will ensure that more intelligence can be applied to each sub-problem and time will be saved. Some design problems such as buildings, cars, machine tools, etc., will have to be dealt with integrity and will not permit splitting. Splittable design problems such as industrial plants, electricity supply networks, and similar systems, may require that the design team has a leader who gives main and critical decisions. In cases where the necessary design experience is missing and there is risk of making errors, experience may have to be generated artificially through research and experiments. Particularly in such cases neither glass box nor black box methods will suffice, and designers will be in need of other design methods.

3. Control over the Design Process - Designers as Self-organising Systems

With the *black box* and *glass box methods*, the designer generates many alternatives difficult to assess within the limited time allowed. The designer has either to try out all the alternatives through conscious thought, which may not be feasible, or he has to use intuition to decide upon one of them. In the third group of methods Jones (1980) classifies, the designer divides the design effort between *carrying out* the search for a suitable design through alternatives; and *controlling* and *evaluating* the manner of search, also called *strategy control*. Strategy control will have to provide an accurate model of the strategy itself, and of the external situation into which the design will fit. This model of *self-plus-situation* (or *strategy-plus-objective*) is to provide the member of the design team with a guide in deciding upon search actions and observing whether they produce an acceptable balance between the new design, the situations influenced by the design, and the cost of designing. Jones (1980) suggests that strategy control disintegrates the design process into the *analysis-synthesis-evaluation* stages and decides on which methods to employ for the realisation of each. The three stages can be considered as breaking a design problem into pieces, bringing them back together under a new structure, and testing the consequences of this new structure. This cycle may have to be repeated, each time in more detail.

Jones (1980) reinterprets these three stages as *divergence*, *transformation* and *convergence*. *Divergence* is the act of extending the boundary of the search space of a design situation to make it large and fruitful enough in which to seek a solution. The objectives of divergent search are in general unstable and tentative; the problem boundary is undefined; it involves fact-finding rather than speculating on a subject. No possible solution is disregarded if it seems to be relevant to the problem. *Transformation* is the stage of designing, when the general character of the design is established through judgements of values and of technicalities combined with decisions reflecting political, economic and operational realities of the situation. It is also a stage where critical mistakes can be made with wishful thinking or narrow-mindedness, or not using valid experience and sound judgement. The objectives and problem boundaries are fixed, critical variables are identified, constraints are determined. The personal aspects of the design activity become here evident. *Convergence* is the stage that follows when the design problem has been defined, the variables identified and the objectives determined. At this stage, the designer reduces the uncertain alternatives until one alternative design is left as the final solution. As this decision has to be managed with economy of time and resources, methods of convergence may require rigid applications of *glass box methods*.

2.6. DETERMINING THE APPROPRIATE STRATEGY

Jones (1980) describes determining the design strategy as determining which methods to choose and combine, to define the actions to be carried out by members of the design team within the design process. In some cases, a single method may be enough to carry out the design process, then that method becomes the strategy itself. For the selection of design methods, Jones (1980) offers a table he calls the *input/output chart (Table 2.6.1.)*. Depending on what the designer already has as input (the kinds of information that have to be available for the methods to be employed, listed on the left column), and what he wants to achieve as output (listed on the top row) helps in the selection of the methods. The methods are listed in the boxes where the inputs and outputs cross, and in the columns below. A method may appear more than once on the table, as back-tracking in the process may be necessary and these methods would be employed for this activity.

The table lists methods of *divergence, transformation* and *convergence*; it also offers methods of strategy control and already developed design strategies as combinations of methods. Although Jones brings considerable criticism to the methods in the list and offers the table as being incomplete and tentative, the table is worth noting, as it is a summary of the design methods employed by designers and engineers when design methods became popular as a design tool. Many of these methods are used today as techniques for making research, collecting, noting and reducing data, and generating ideas. However, as the design strategies that Jones (1980) also calls *prefabricated strategies* are developed for predefined problem structures, they may not be conveniently applied to other problems related to novel design situations. The methods listed in the table are categorised as follows:

Methods of Exploring Design Situations (Methods of Divergence)

- Stating Objectives
- Literature Searching
- Searching for Visual Inconsistencies
- Interviewing Users
- Questionnaires

* Investigating User Behaviour
* Systemic Testing
* Selecting Scales of Measurement
* Data Logging and Data Reduction

Table 2.6.1. Input-Output Chart for Selecting Design Methods (Table from Jones, 1980: 80).

OUTPUTS → INPUTS ↓	2 **Design Situation Explored**	3 **Problem Structure Perceived or Transformed**	4 **Boundaries Located, Sub-solutios Described, and Conflicts Modified**	5 **Sub-solutions Combined into Alternative Designs**	6 **Alternative Designs Evaluated and Final Design Selected**
1 **Brief Issued**	Stating Objectives Literature Searching Visual Inconsistency Search Interviewing Users Brainstorming	Literature Search Visual Inconsistency Search Interviewing Users Brainstorming Synectics	Visual Inconsistency Search Brainstorming Morphological Charts	Visual Inconsistency Search Brainstorming Synectics	Strategy Switching Matchett's FDM
2 **Design Situation Explored**		Stating Objectives Data Reduction Interaction Matrix Interaction Net Classification Specification Writing		System Transformation Functional Innovation Alexander's Method	
3 **Problem Structure Perceived or Transformed**	Literature Searching Questionnaires Investigating User Behaviour Systemic Testing Selecting Measurement Scales Data Logging		Boundary Searching Systemic Testing Brainstorming Morphological Charts Selecting Criteria Ranking and Weighting Specification Writing	Brainstorming Synectics System Transformation Boundary Shifting	Systemic Search Value Analysis Systems Engineering Man-machine System Designing Boundary Searching Page's Strategy CASA
4 **Boundaries Located, Sub-solutios Described, and Conflicts Modified**		Synectics Removing Mental Blocks AIDA System Transformation Boundary Shifting Functional Innovation Alexander's Method		Brainstroming Synectics Removing Mental Blocks AIDA	AIDA
5 **Sub-solutions Combined into Alternative Designs**					Value Analysis Questionnaires Investigating User Behaviour Systemic Testing Selecting Measurement Scales Data Logging and Reduction Checklists Selecting Criteria Ranking and Weighting Specification Writing Quirk's Reliability Index
6 **Alternative Designs Evaluated and Final Design Selected**					

Methods of Exploring Problem Structure (Methods of Transformation)

* Interaction Matrix
* Interaction Net
* AIDA (Analysis of Interconnected Decision Areas)

- System Transformation
- Innovation by Boundary Shifting
- Functional Innovation
- Alexander's Method of Determining Components
- Classification of Design Information

Methods of Searching for Ideas (Methods of Divergence and Transformation)
- Brainstorming
- Synectics
- Removing Mental Blocks
- Morphological Charts

Prefabricated Strategies (Methods of Convergence)
- Systematic Search (The Decision Theory Approach)
- Value Analysis
- Systems Engineering
- Man-Machine System Designing
- Boundary Searching
- Page's Cumulative Theory
- CASA (Collaborative Strategy for Adaptable Architecture)

Methods of Evaluation (Methods of Convergence)
- Checklists
- Selecting Criteria
- Ranking and Weighting
- Specification Writing
- Quirk's Reliability Index

Strategy Control
- Strategy Switching
- Matchett's Fundamental Design Method (FDM)

2.7. DISCUSSION OF SEVERAL SELECTED DESIGN STRATEGIES

Among the methods listed above, three strategies are chosen to discuss at more length.

1. *Page's Cumulative Strategy* (listed under the category of *Prefabricated Strategies*) aims at increasing the amount of design effort spent on the cumulative and convergent stages of *analysis* and *evaluation*, and at decreasing the effort spent on the *synthesis* of solutions (Jones, 1980). For the cumulative stages, the critical aims, such as those that have to be achieved for a design solution acceptable by the sponsor, the users, etc., are identified. The external factors that may prevent the achievement of these aims are determined; the unambiguous criteria by which unacceptable design solutions may be recognised are defined. For each criterion, a test that precisely discriminates between acceptable and unacceptable solutions is devised; tests that affect the numerous alternative solutions are applied first. For the non-cumulative stages, numerous alternative design solutions are developed for each criterion and rough models are made for extreme solutions. The tests are applied to the models, until one set of sub-solutions remain. To deal with design conflicts, further tests may be designed to understand the effects of several criteria simultaneously; to eliminate the conflicts, new ways may be sought to combine sub-solutions. The primary aim of this strategy is to eliminate the time and effort spent on trial-and-error in the design process and was primarily developed for the designing of buildings and

other complicated artefacts. Projects of such scale though, require close interaction between details and major design decisions, and as Page's Cumulative Strategy offers a linear strategy, it may be difficult to apply in cases of complicated interactions. The strategy also requires data and measuring techniques for the identification of the critical criteria, and therefore offers control over decision-making, and is suitable for collaboration within a team of specialist designers at the early stages of a project.

2. *Matchett's Fundamental Design Method* (FDM, listed under the category of *Strategy Control*) aims at making it possible for the designer to see and control his pattern of thoughts, and to relate this to all aspects of the design situation (Jones, 1980). Matchett and Briggs (1966) explain that a designer has to be aware of the mental skills and attitudes he employs while designing to be able to improve his design ability. With this belief, a Fundamental Design Course was developed at the Engineers' House in Bristol for training designers towards the use of the following modes of thinking (as summarised by Jones, 1980):

- Thinking with outline strategies: Includes the ability to decide in advance what strategy to use, the ability to compare what is achieved with what was planned, and the ability to develop strategies to produce strategies.
- Thinking in parallel planes: Is done to be aware of the degree to which the designer is in control of his thoughts, and of his colleagues, and of how much his colleagues are in control of him. It requires the detached observation of the designer's and of the group's thoughts and actions.
- Thinking from several viewpoints: Is directed at the solution rather than at the process of finding it. It is done by stating objectives by describing the product as something that *provides a means* (PAM).
- Thinking with concepts: Involves drawing geometric patterns that helps the designers to relate their thoughts with the FDM checklists they choose to employ. Its aim is to make the designer remember and visualise the relationships between the problem, the process and the solution.
- Thinking with basic elements: Proposed by Matchett are what he also calls *Techtams* (spelt opposite of Matchett), words used to make the designer aware of the many alternative actions that come forth at each stage of decision-making. The words are grouped as follows:

Group 1. Recognise need. Recognise inevitable element. Imagine decision. Tentative decision. Firm decision. Cancel decision.

Group 2. Assume. Weigh. Weigh and compare. Extrapolate. No further action. Predict.

Group 3. Continue in same direction. Continue plus increment. Change direction. Back check. Advance check. Scan. Resolve conflict. Continue with increased effort. Recall.

Group 4: Assess risk. Check consequences. Develop. Compare with another decision. Divide action. Adapt another decision. Concentrate on small area. Factorise. Check cause. Question further decision. Reverse decision. Try alternatives.

Group 5: Store decision. Expose relationship. Delay decision. Communicate decision. Relate to previous decision. Search for redundancy. Search for inadequacy.

Group 6: Use concept. Change plane of abstraction. Use outline strategy. Change viewpoint. Compare with existing system. Compare with emerging system. Apply *primary roulette*. Apply *secondary roulette*.

Group 7. By-pass obstacle. Destroy obstacle. Remove obstacle. Commence new action from zero. Commence new action from decision. Actions in one, two, three or more dimensions.

These modes of thinking are used to control and extend the designer's pattern of thought, after which the FDM design sequence and checklists are used to explore the design situation and to develop a solution. The phases of FDM suggested in Matchett and Briggs (1966) illustrates how the design sequence can be:

1. Investigating the primary functional need that has to be satisfied for the success of the design solution (using design trees or game trees may be a method; PAMs are defined at this stage).
2. Making sketches as suggestions for the primary functional need.
3. Preparing a list of factors or items, and the functional means they provide.
4. Eliminating, combining or transforming these items or whole sections of the design through interaction matrices.
5. Using the functional process chart to represent the sequence of design activities to take place (*Figure 2.7.1.*).
6. Representing the operational variations through a chart (such as the design tree).
7. Using the functional process chart to represent the new design.
8. Studying the way the design operates through drawings and models.
9. Preparing sketches and drawings for the components of the mechanism of the design.
10. Preparing the prototype to check the correctness of the design.
11. Preparation of final drawings.
12. Representing the functional effectiveness of the design to test.
13. Investigating the outcomes of the field application.
14. Preparing a histogram showing the relative usefulness of each scheme in relation to and compared to each other to help implementation.
15. Releasing the design for trail production.

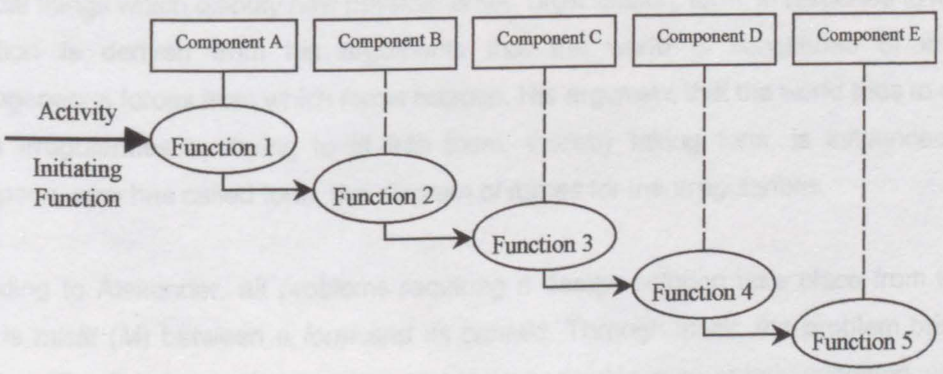


Figure 2.7.1. Functional Process Chart (Figure adapted from Matchett & Briggs, 1966: 193).

This example shows that the sequence does not have to be rigidly applied, but can be modified, depending on the design problem. It also shows how backchecks are integrated into the linearity of the sequence, and how the sequence is used to control, evaluate and check decisions. A set of questions is offered to help guide the sequence (Jones, 1980: 184-185):

'a. Which of the needs are –vital? –very important? –important? –desirable?

b. What are the needs of –the functional system? –the customer? –the company? –the outside world?

c. What are the needs at each of ten product life stages –designing and drawing? –development? –production and components? –assembly? –testing and adjusting? –finishing and packaging? –distribution? –installation? –usage and misusage? –maintenance and servicing?

d. What can be learnt by asking the six fundamental questions of work study –what has to be done? (needs) –why has it to be done? (reason) –when has it to be done? (time) –where has it to be done? (place) –by what or whom has it to be done? (means) –how has it to be done? (method)

e. How can each part of the design be –eliminated? –combined? –standardised? –transferred? –modified? –simplified?

f. What –effects –demands –restrictions will each item in a set have, on every other item in the set when compared using an interaction matrix?'

The question groups a., b., c., d. and e. are called the *primary roulette*, and group f. is called the *secondary roulette*. The *primary roulette* intends to generate numerous design alternatives and the *secondary roulette* intends to ensure that changes taking place are compatible with each other and with the needs. *Matchett's Fundamental Design Method*, which requires training in advance, has been criticised for its deliberately manipulative ways of interfering with the thinking process, at times to the extremes of brainwashing. Another criticism has been that the results achieved would be no different than those attained through any such concentrated thinking and design activity. All the same, this systematic approach has been used extensively (Jones, 1980).

3. *Alexander's Method of Determining Components* is developed by an influential design thinker in the 1970s, Christopher Alexander (1970: 1), who defines design as 'the process of inventing physical things which display new physical order, organisation, form, in response to function'. His definition is derived from his arguments that the world is constituted of irregular and heterogeneous forces from which forms happen. His argument that the world tries to compensate for its irregularities by trying to fit into them, thereby taking form, is influenced by D'Arcy Thompson, who has called form, the *diagram of forces* for the irregularities.

According to Alexander, all problems requiring a design solution take place from the fact that there is *misfit* (*M*) between a *form* and its *context*. Through misfit, the problem brings itself to attention. The fit between form and context in an ensemble is an orderly condition, which can be disturbed in various ways; fit is a potential misfit. Alexander represents the state of each potential misfit with a binary variable: if the misfit occurs, the variable takes the value 1; if it does not occur, the variable takes the value 0. The value of the variable represents a state of affairs among many, in the relation between form and context. Design has the task of creating an order in the ensemble where all variables take the value 0. The aim of design is thus to achieve fitness between form, and the context that defines it. As the designer has only control over the form part of the ensemble of form and context, it is through form that order will be created. Fitness between form and context is a relation of mutual acceptability, and by solving a design problem, as Alexander (1970: 19) puts it, the designer puts them into 'effortless contact' or 'frictionless coexistence'.

In the process of form-making, Alexander's aim is to attain a diagram of forces to represent the form of a design. In order to understand the design problem, he suggests that the designer sets up a hierarchy of concepts, a set of requirements represented in the form of a tree, each requirement standing for a potential misfit. The misfits are patterned into categories. Each misfit variable (M) in the system is represented with a point, and each causal linkage (L) with a line between two points (*Figure 2.7.2.*). The *independencies* between the points help in determining the sub-systems of the problem, and points to which ones can operate independently. The interlinked, yet sufficiently free series of sub-systems strive to adjust. This process of adaptation occurs during the cycles of correction and recorrection and is restricted to one sub-system at a time.

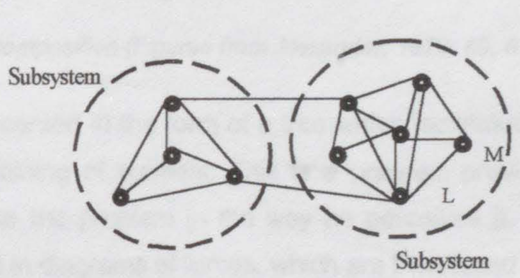


Figure 2.7.2. Links between Misfits forming subsystems (Figure adapted from Alexander, 1970: 65).

Alexander suggests that, this representation makes the problem condensed, easier to discuss and study. Ideally, the complexity of a problem has to be fully disentangled and the problem stripped from all preconceptions in order to understand its organisation. The issues most clearly expressed carry the greatest importance in a design decision, and are best reflected in the form. The concepts that are chosen to define certain aspects of the problem (also determining the requirements, therefore the misfit variables) have to be carefully used. If not well related to the same subsystem (*Figure 2.7.3.*) their use may bring a peculiar and deranging arbitrariness.

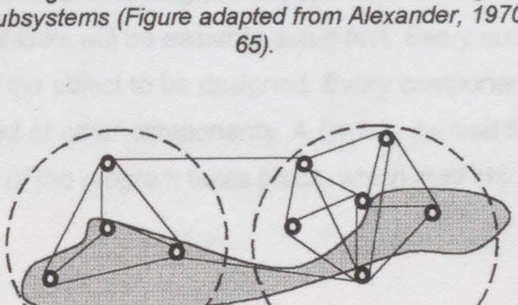


Figure 2.7.3. Arbitrariness of concept that is not well related to the same subsystem (Figure adapted from Alexander, 1970: 65).

So, the first phase of the design problem is carried out for finding the right *design program*. This is the analytical phase, the starting point is the *requirement*, the end product is a *tree of sets of requirements*. The second is the synthetic phase; the starting point is the *diagram*, the end product the *realisation of the program*, in the form of a tree of diagrams. Each constructive program can be assumed as a tentative assumption about the nature of the context; it can be considered as a hypothesis relating an unclear set of forces conceptually; improved by clarity; obtained by abstraction and invention; 'rejected when a discrepancy turns up and shows that it fails to account for some new force in the context' (Alexander, 1970: 92). The program is a hierarchy of the most significant subsets of misfits. Each subset forms a sub-problem with its own integrity, and they fall together to become part of larger sets, which are themselves parts of larger sets (*Figure 2.7.4*).

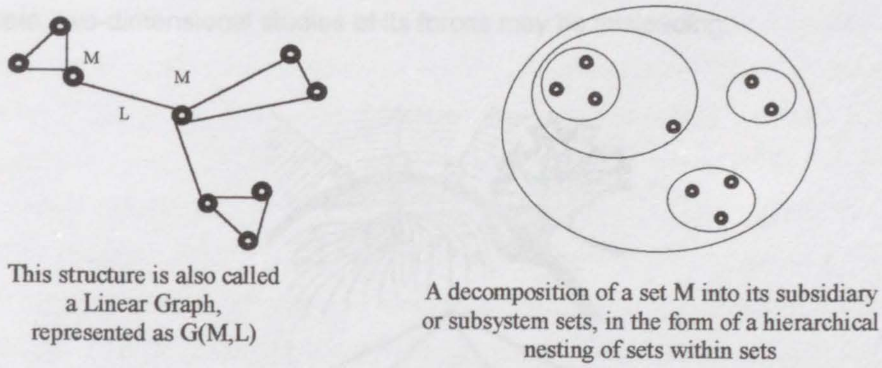


Figure 2.7.4. A linear graph and nesting sets of decomposition (Figures from Alexander, 1970: 80, 81).

The nesting sets of decomposition is then represented in the form of a tree which facilitates the understanding of immediate relations and combining of subsets. This is a program providing direct instructions for the designer to reorganise the problem in the way he perceives it. The physical implications of the subsets are identified in diagrams of forces, which are then fused with others, not an easy task as the physical requirements of one diagram will conflict with another's. In this case, the subsets with the weakest internal links will be easier to solve first. Every subset solved as a force diagram is now a component of the object to be designed. Every component is a *unit* of another component, and a *pattern* formed of other components. A *form* is derived from the *program*, in Alexander's words, the *realisation of the program* takes place, which may also be called a *synthesis of form (Figure 2.7.5.)*.

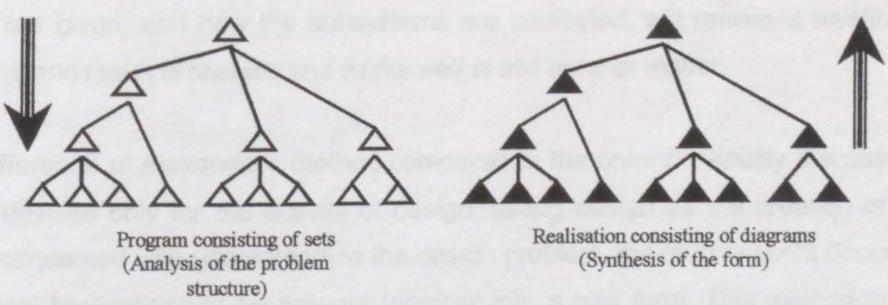


Figure 2.7.5. Analysis of the problem structure, and the synthesis of form (Figures from Alexander, 1970: 94).

Alexander's method of design is thus founded on the assumption that the world is based on a pattern of interactions, which take form as a result of forces. This is an interesting abstraction for design situations, though Alexander's method too has been subject to criticism. In determining the interrelationships between misfit variables in a graph, Alexander suggests using pure mathematics with probability calculations; and depending on the circumstances the designer may face a large number of alternative combinations to be considered. Another point is that, some problems may particularly have to be solved in integrity rather than starting from solving sub-problems and combining these solutions. Finally, Alexander's diagrammatic view of the problem, and the relation of units and patterns may be considered an approach too good to be true. Alexander solves problems literally through two-dimensional diagrams of forces, as he believes forces are the inner drives of form. But as form is three-dimensional, and as problems can be of very large scale, two-dimensional studies of its forces may be misleading.

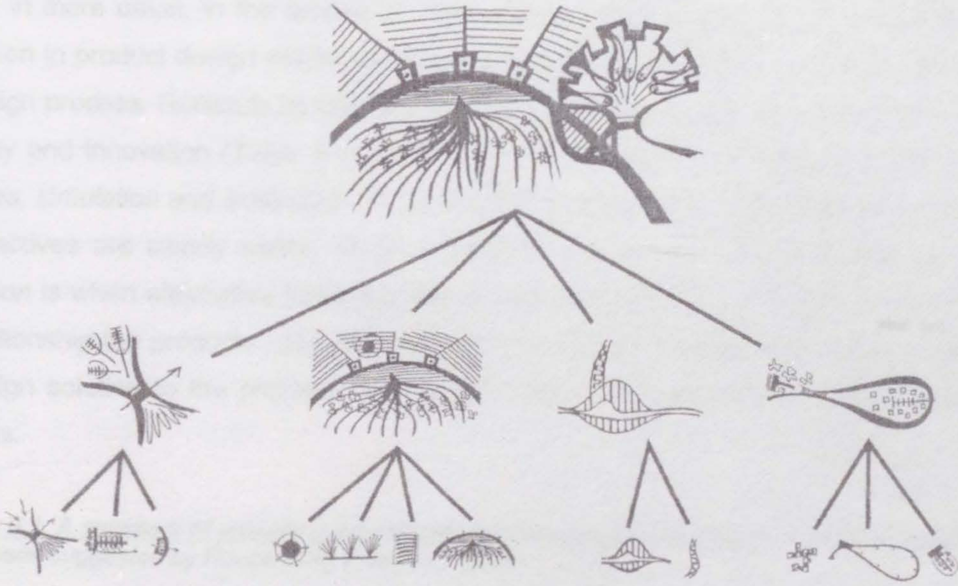


Figure 2.7.6. The organisation of the Indian Village prepared according to the study and synthesis of components (Alexander, 1970:153).

As in his example of the way the components of the agricultural Indian Village (Figure 2.7.6.) have been determined, it seems that such a synthesis remains very much related to the creative skills and representational abilities of the designer. Although the study on how the components are related to each other shows well how the decomposition can work, how the forces take the form they are given, and how the subsystems are combined, will remain a mystical question. Whether the end result is realistic and works well is still another matter.

A major difference of Alexander's method compared to the ones previously discussed is that, it has been devised only for the activity of design, taking design as the creation of forms. The method is concerned with understanding the design problem, the requirements decomposed into their physical implications to be brought together into a new form. This method is particularly important as it has been devised by a designer (architect) rather than a person from an engineering background, and is a guide for the actual design act within the design process.

3. DESIGN METHODS AS DISCUSSED TODAY

In recent years, new design methods have been devised in accord to developments in the understanding and application of design processes. The design process has become deeply involved with product development, which is part of industrial innovation, and thus is closely related to subjects such as business economics, basic and applied research, marketing research and planning, production, distribution, sales and after sales service (Roozenburg & Eekels, 1995). In *Section 4.3.*, such new approaches will be discussed and models developed will be studied in more detail, in the context of 'total design'. Here, the recent methods that allow for innovation in product design will be classified as to the general character of their approaches to the design process. Roozenburg and Eekels (1995) group methods (*methodics* in their word) for creativity and innovation (*Table 3.1.*) according to the phases of the design process: *analysis*, *synthesis*, *simulation* and *evaluation*. In the *analysis* phase, the design problem is analysed and the objectives are clearly stated. In the *synthesis* phase, ideas are generated for solutions. *Simulation* is when alternative ideas are tested to assess their impacts on the environment and the relationship the products have with the users. *Evaluation* is when a final idea is selected as the design solution to the problem. The recent design methods will be reviewed under these headings.

Table 3.1. A summary of recently used methods for creativity and innovation in the design process (Methods suggested by Roozenburg & Eekels, 1995)

Methods for Analysis	Methods for Synthesis	Methods for Simulation	Methods for Evaluation
• Making a Design Specification	(Creativity Methods)	• Structure models	• Heuristic Decision Rules
- Checklists	• Association Methods	• Iconic models	- The Conjunctive Rule
- Operationalising Objectives	- Associations	• Analogue models	- The Disjunctive Rule
• Quality Function Deployment	- Brainstorming	• Mathematical models	- Elimination by Aspects
	- The 6-3-5 Method		• Decision Methods for Multi-Criteria
	- Brainwriting Pool		- Ordinal Methods
	- Checklists		*The Majority Rule*
	• Creative Confrontation Methods		*The Copeland Rule*
	- Analogies and Chance		*The Rank-sum Rule*
	- Synectics		*The Lexographical Rule*
	- Random Stimulus		*The Datum Method*
	- Intermediate Impossible		*New Product Profiles*
	- Concept Challenge		- Cardinal Methods
	• Analytic-Systematic Methods		*The Weighted Objectives Method*
	- Function Analysis		*The Additive Value Function*
	- The Morphological Method		
	- Analysis of Interconnected Decision Areas (AIDA)		

3.1. ANALYSIS

As Ackoff and Sasieni (cited in Roozenburg & Eekels, 1995) state, uncertainty about the solution is an essential characteristic of problems. Analysis in the design process is done to fully understand the design problem and to bring forth a *design specification*. A design task generally begins with the statement of the *goal*, that is, the image of the desired future situation, generally related to the mind (*Figure 3.1.1.*). Statements about the goal, the *objectives*, when listed, form the design specification. The aim of stating objectives is to distinguish: the persons involved; the aspects of the design, and the life cycle of the product. A specification may contain *scaling* and *non-scaling objectives*. *Scaling objectives* are those that allow a ranking of the order of the alternative design proposals as to the extent they meet the objective. An objective is *non-scaling* if it allows only one solution.

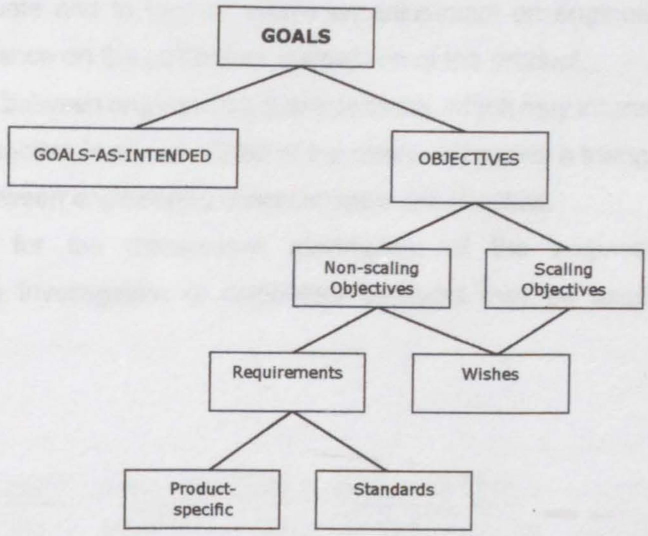


Figure 3.1.1. Classification of goals and objectives (Figure adapted from Roozenburg & Eekels, 1995: 137).

Objectives essential for reaching the goal will be *requirements*. Some objectives will only be desirable, such as *wishes*. Many objectives will be specific, applying to a particular product, use or user group; these are *standards*. Design specification, also known as *performance specification*, *product design specification*, *engineering specification*, or *list of requirements*, is an elaboration of the goal in the form of a list of normative statements about the properties the product should have, setting limits to the solution space, and to be used to select appropriate solutions (Roozenburg & Eekels, 1995). The authors particularly stress that this list does not specify the solution but may provide criteria by which outcomes will be judged; also facilitating the management process where design tasks are carried out by team work.

Among the analysis methods that are found applicable with valid results, is the *Quality Function Deployment* (*QFD*), developed in Japan in the mid 1970s (Pugh, 1996). This is a systematic process by which a multifunctional team deploys from 'the voice of the customer to operations on the factory floor' (*Figure 3.2.4.*). Cross (2000) describes the steps of this method as follows:

1. The customer requirements are identified in terms of product attributes, through market research techniques.
2. The relative importance of the attributes are determined, through market research techniques or by asking customers to rank.
3. The attributes of competing products are evaluated.

4. A matrix is drawn with product attributes against engineering characteristics, to identify which characteristics affect which attributes. Attributes are written as rows, with their relative weights; characteristics as columns. Each intersecting box is a potential interaction or relationship. Down the right edge of the matrix are the resulting scores. The same matrix for competing products will allow comparison of scores.
5. The relationships between engineering characteristics and product attributes are identified through the cells of the boxes, not all of equal value. Numbers representing these relationships may be used to valuate and to identify where an adjustment on engineering characteristics will result in an influence on the customers' perception of the product.
6. Relevant interactions are identified between engineering characteristics, which may interact in a positive or negative way. A new section is added on top of the matrix to provide a triangular shaped roof, where interactions between engineering characteristics are checked.
7. Target figures to be achieved for the measurable parameters of the engineering characteristics are set. Again, an investigation of competitor products may be used as support.

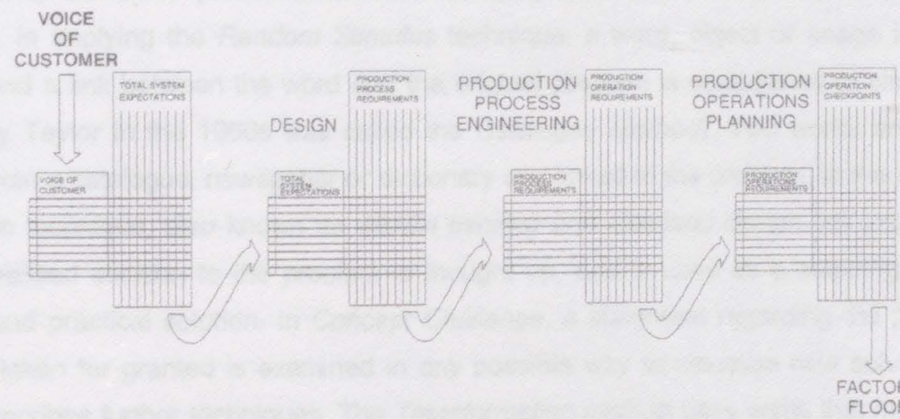


Figure 3.1.2. Basic Quality Function Deployment (Figure from Pugh, 1996: 185).

Analytical methods are thus employed mainly during the determination of design specifications, preceding the solution finding stage.

3.2. SYNTHESIS

Methods for synthesis are employed during the design process wherever ideas are generated for solutions, at the level of principles or of details. Roozenburg and Eekels (1995) relate the phase of synthesis with the methods for creativity, also considered as *creativity techniques*. As seen in *Table 3.1.*, the three categories are: *Association Methods*, *Creative Confrontation Methods*, and *Analytic-Systematic Methods*, classified under *heuristic* principles, and mainly depending on experience. Yet, creativity itself depends on certain factors, as Roozenburg and Eekels (1995) note: on domain-relevant skills, creativity-relevant skills (creativity methods can only enhance these skills), and task motivation.

Among the *Association Methods* cited in *Table 3.1.*, some have been previously discussed or referred to. The *6-3-5 Method* requires six participants to write down three ideas on forms that are passed around five times among the participants, each time the participants adding new ideas, thus collecting 108 ideas in a short time. The *Brainwriting-pool Method* (developed by the Batelle Institute in Frankfurt), a derivation of brainstorming, has five to eight participants note four ideas after the problem is explained. The notes are put in a pool, from which each participant pulls out one, adding new ideas and suggestions, which are then collected and evaluated. Association methods have been developed for individual use as well, like *Taylor's Structured Free Association*. The designer writes down a symbol (a word, figure, object or condition) linked to the design problem. Every thought that occurs in connection with this item is written down. The list is studied and thoughts that seem important to the problem are chosen. Solutions are developed for the chosen thoughts. If necessary, a new symbol is chosen to repeat the process.

From among the *Creative Confrontation Methods*, *analogies* and *synectics* have already been mentioned in Sections 2.5. and 2.6.. The following three techniques related to lateral thinking, discussed by De Bono (1970; cited in Roozenburg & Eekels, 1995), in principle resemble *synectics*. In applying the *Random Stimulus* technique, a word, object or image is chosen at random and a link between the word and the original problem is established (a similar method offered by Taylor in the 1960s was called the *Catalogue Method*). Two words are chosen at random from a catalogue, newspaper or dictionary and linked to the problem. In the *Intermediate Impossible* technique, also known as *wishful thinking* and *idealised design*, an impossible and highly idealised solution to the problem is thought up, and is used as a stepping stone for a realistic and practical solution. In *Concept Challenge*, a statement regarding the problem and normally taken for granted is examined in any possible way to visualise new solutions. Cross (2000) describes further techniques. The *Transformation* method uses verbs that may transform the problem during the search for solution from one area to another. *Why? Why? Why?* method asks this question persistently until a dead end is reached, or an unexpected answer emerges. *Counter-planning* is taking an idea or solution and its opposite, to seek a compromise between the two, using the best feature of both to bring out a solution.

Pahl and Beitz (1996) make a brief review on other methods that support systematic work. In the *Method of Persistent Questions,* a standard list of questions are asked frequently as a stimulus to fresh thought and intuition, and using checklists in its application. In the *Method of Deliberate Negation*, a known solution to the design problem is split into individual parts or described by individual statements. Each part or statement is negated, often resulting in the creation of new solution possibilities. In the *method of forward steps* (also called the *Method of Divergent Thought*), a first solution attempt is made, and following as many paths as possible, further solutions are generated. Although the method may begin with unsystematic divergence, it may result in systematic variations of the characteristics. In the *Method of Backward Steps* (also called the *Method of Convergent Thought*), the final objectives of the development are stated, and all the possible paths that could have led up to it, are traced back. This method is used particularly for drawing production plans and developing systems for the production of components. The *Method of Factorisation* is used to break down a complex interrelationship or system to less complex and more easily definable individual elements, each sub-problem being solved individually, its links with the system, kept in mind. The *Method of Systematic Variation* is used to determine the required characteristics of the solution, through a schematic representation of the various characteristics that help in the discovery and development of solutions.

Cross's (2000) account for general methods for synthesis are listed under two headings: *conventional* and *intuitive methods*. Among the *conventional methods* are: *Literature Search* for a review on up-to-date data that may be found in books, journals, patent files, etc.; *Analysis of Natural Systems* applied to the study of natural forms, structures, organisms and procedures that may provide connections between biology and technology; and *Analysis of Existing Technical Systems,* a method used for the study of existing technical systems to discover related logical, physical and embodiment design features.

Among the *intuitive methods* are: *The Gallery Method,* where the group members think on the given design problem intuitively, individually for 15 minutes and generate solutions through sketches and texts. The generated alternatives are hung on the wall for the group members to discuss. For another 15 minutes, new associations are made, or the proposals improved. The generated ideas are again reviewed and classified, and promising solutions are chosen to be finalised. *The Delphi Method*, suitable for longterm development is where experts in a particular field are asked for their opinions in three rounds. In the first round, they are asked for starting points for solving the given problem; in the second, to go through a list of various starting points and add further suggestions; in the third, an evaluation of the first two rounds are presented, and the experts are asked to make suggestions on the ones they find most practicable.

Rosenman and Gero (1993; cited in Cross, 1997) suggest four procedures which may yield in creative design, namely: *combination*, *mutation*, *analogy* and *first principles* (*Figure 3.2.1.*). *Combination* is a procedure in which features of existing designs are combined into a new configuration. *Mutation* involves the modifying of the form of a particular feature or features of an existing design, to transform it towards a novel form. *Analogy* uses a concept to describe another and to suggest it in an altered form, abstracting its behavioural features.

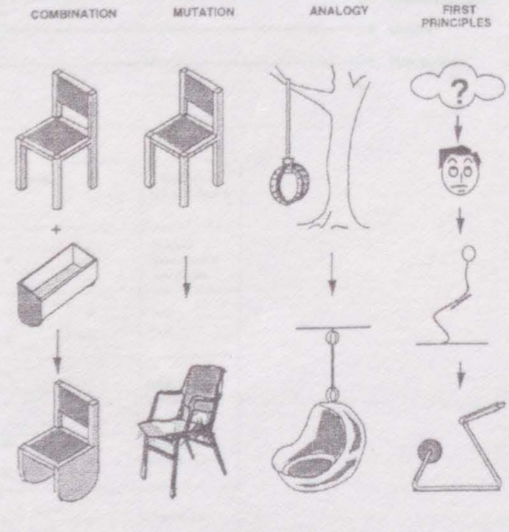


Figure 3.2.1. Representation of the procedures of creativity: combination, mutation, analogy and first principles, by Rosenman and Gero (1993; cited in Cross, 1997: 433).

First principles utilises the expectations from a design situation, or the behaviours that result from the situation as concepts, in the generation of designs. Though difficult to determine, *first principles* are at the core of any design situation as they identify the requirements or desired functions, to shape them into appropriate forms or structures.

The *Analytic-Systematic Methods*, another category of methods for synthesis, differ in nature as they require the use of a combination of methods in order to analyse the design problem and then to systematically bring together or eliminate alternative solutions (Roozenburg & Eekels, 1995). For instance, the *Function Analysis Method* considers the product as a technical-physical system in which each function is described as a *transformation process* between a given initial state and a desired final state.

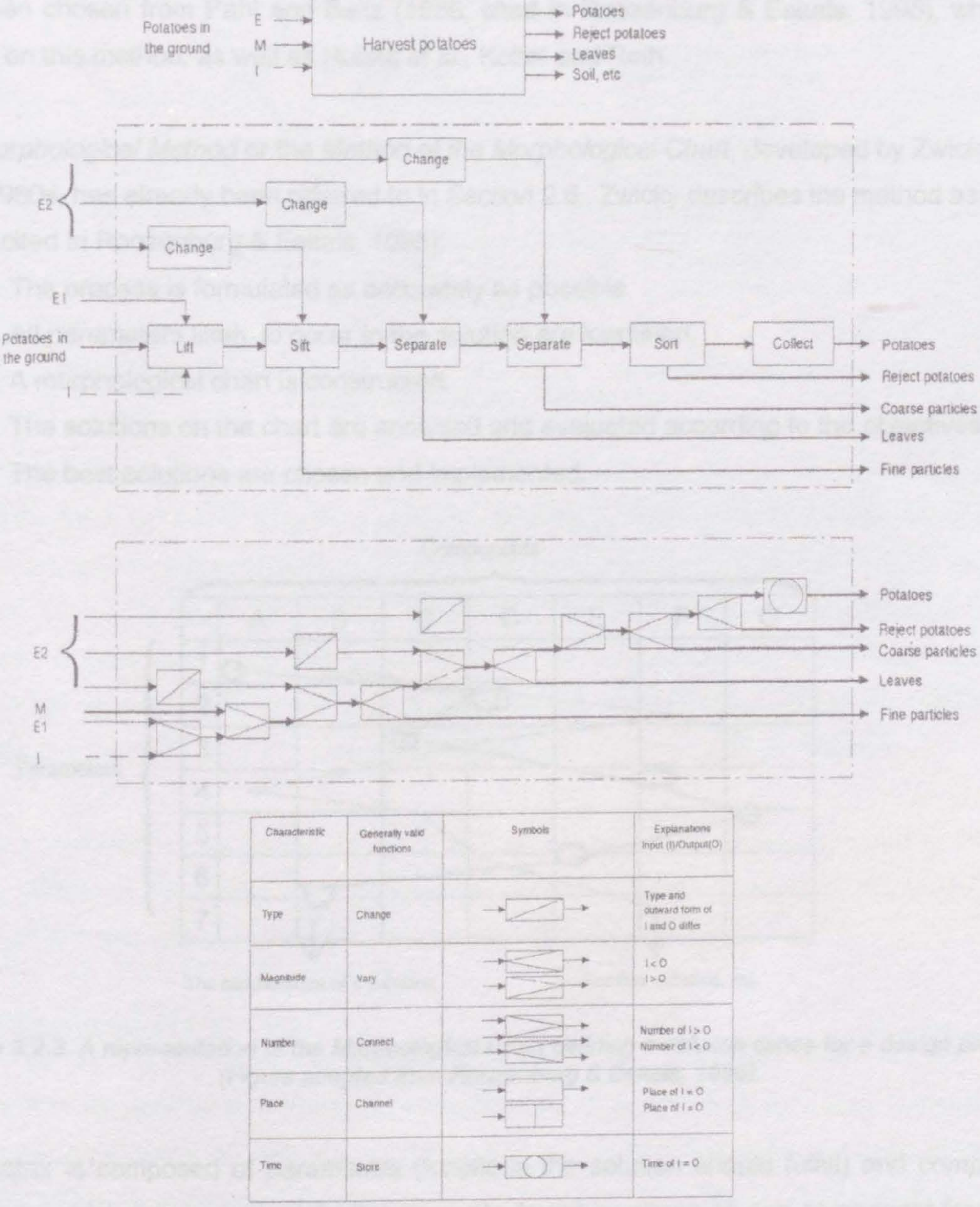


Figure 3.2.2. Function structure of a potato harvesting machine and symbols for general functions by Pahl and Beitz, 1986 (cited in Roozenburg & Eekels, 1995: 197-198).

In this process are three fundamental variables: *matter*, *energy* and *information*. The method aims at determining the essential characteristics of the new product in an abstract manner, and thus considers as large a field of probable solutions as possible. In the first step, the main function of the product is described in the form of a *black box*, in terms of transformations in flow of matter, energy and information. The input and output characteristics are determined. In the second step, the main technical processes in the product are described to develop a simple function structure as a whole of sub-functions. Either an already existing solution may be analysed, the components and parts studied and compared, then translated into functions; or, the functions structure may be synthesised by means of elements from a collection of elementary, general functions. In the final step, the second step is elaborated; the functions left out are fitted in. Variation possibilities are studied. The example (*Figure 3.2.2.*) of a potato harvesting machine has been chosen from Pahl and Beitz (1986; cited in Roozenburg & Eekels, 1995), who have written on this method, as well as Hubka *et al.*, Koller and Roth..

The Morphological Method or the *Method of the Morphological Chart*, developed by Zwicky in the early 1960s, has already been referred to in *Section 2.6.*. Zwicky describes the method as follows (1966; cited in Roozenburg & Eekels, 1995):

Step 1. The process is formulated as accurately as possible.

Step 2. All parameters likely to occur in the solution are identified.

Step 3. A morphological chart is constructed.

Step 4. The solutions on the chart are analysed and evaluated according to the objectives.

Step 5. The best solutions are chosen and implemented.

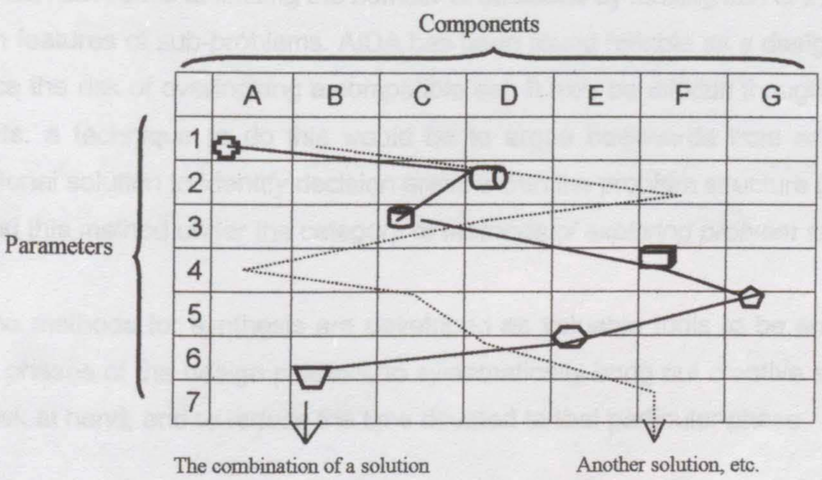


Figure 3.2.3. A representation of the Morphological Chart defining a solution space for a design problem (Figure adapted from Roozenburg & Eekels, 1995).

This matrix is composed of *parameters* (functions the solution should fulfill) and *components* (means by which this is achieved). Solutions are found by choosing one component from each row per parameter, thus combining the sub-solutions systematically (*Figure 3.2.3.*). To overcome the fact that there may be a great number of solutions to choose from among, the parameters intelligently chosen should be independent of each other; the essential parameters should be found and the rest ranked according to their order of importance, to be able to make decisions on the elimination of less important elements and less likely solutions.

The *Analysis of Interconnected Decision Areas* (*AIDA*) is used for problem situations in which a number of interdependent decisions have to be taken (Roozenburg & Eekels, 1995). In each decision area are listed options, which are later represented in an *option graph* (*Figure 3.2.4.*). Between two incompatible options, a line is drawn to indicate that they cannot be united in one design, for a reason, thus relying on systematic decisionmaking on incompatibilities (Roozenburg & Eekels, 1995). From the rest can be combined possible solutions (one option from one decision area).

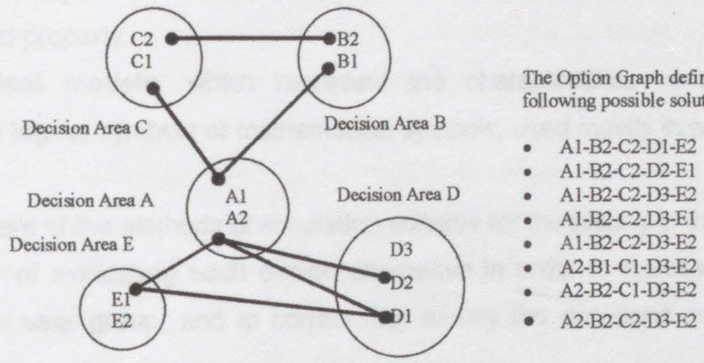


Figure 3.2.4. A representation of an Option Graph (Figure and example from Roozenburg & Eekels, 1995: 211).

As it combines options for achieving solutions, AIDA resembles the morphological method, but differs that, AIDA aims at limiting the number of solutions by making use of the interdependencies between features of sub-problems. AIDA has been found reliable as a design method, as it aims to reduce the risk of overlooking a compatible set. It may be difficult though, to break a problem into parts; a technique to do this would be to argue backwards from an already existing or conventional solution to identify decision areas within the problem structure (Jones, 1980). Jones has listed this method under the category of *methods of exploring problem structure*.

Thus, the methods for synthesis are developed as valuable tools to be employed at the idea-seeking phases of the design process, to systematically bring out creative solutions appropriate to the task at hand; and to reduce the time devoted to that particular phase.

3.3. SIMULATION

Simulation is undertaken to understand the behaviour of the product in relation to the imitated environment and user it is designed for, employing models to simulate the product (Roozenburg & Eekels, 1995), to understand its technical and ergonomic properties in relation to its users, and whether the users will like the product, whether it will be socially and ethically acceptable, and finally to foresee its implications on the environment. The four categories of models used are:

1. **Structure models**, which are based on the qualitative structure of an object or process, and are used to provide an idea on the appearance, functioning and manufacturing possibilities of the design. Examples are circuit diagrams, flow diagrams, sketches and mannikins used to check the range of control devices and supporting surfaces.
2. **Iconic models**, which are material models with which similar conditions with the original design are represented, such as pictures, drawings, dummies, mock-ups, scale models and prototypes. Geometric, static, kinematic, dynamic, thermal, chemical properties of the model should correspond with the original. For the experiments conducted with these models, the environment should be made similar to that of the original situation.
3. **Analogue models**, which are where a property of the original design is represented by another property of the model, to behave in the same manner or in some relation to the represented property.
4. **Mathematical models**, which represent the characteristics of the original, by using particularly logical symbols or mathematical symbols, used mostly in engineering design.

The employment of the methods of simulation suitable for the testing of the designs will thus offer the possibility of evaluating each design alternative in order to assess their performance, the interest of the user group, and to correct and modify the decisions made, through simulated models.

3.4. EVALUATION

Evaluation is done to assess the value of the design, related to the objectives set at the beginning of the process. *Decision making* is choosing among a set of proposed alternatives. These two activities take place all along the design process, in repeated cycles. The evaluation and decision making methods that Roozenburg and Eekels (1995) define, can be applied to any phase in which these activities are carried out. For an evaluative decision to take place, there should be a set of *alternatives*, differing in accordance to the goals and the consequences they will bring.

Heuristic decision rules, as *rules of thumb* may be used as guidelines in taking decisions more or less intuitively. *Conjunctive rules* seek for a satisfying alternative: a certain aspiration level is determined for each criterion, and the first alternative that seems to meet them, is chosen. *Disjunctive rules* seek the *excellent* solution: each alternative is identified with its one best property, and the most valuable property for the situation is chosen. For *elimination by aspects*, an aspiration level is established for each criterion; alternatives are assessed according to the order of importance of the criteria, and those which do not reach the aspiration levels are eliminated.

A brief review of *decision methods for multi-criteria* offered by Roozenburg and Eekels (1995) discusses these methods under two headings: *Ordinal (Qualitative)* and *Cardinal (Quantitative)*

Methods. In *ordinal methods*, alternatives are evaluated for each criterion separately, and ranked per criterion on an ordinal scale, measuring in which alternative the criterion is satisfied. Ordinal data cannot be added to obtain an overall score; the final decision is left to the judgement of the decision-maker, helped also by listing criteria in order of importance. In *cardinal methods*, the decision-maker's judgements on the effectiveness of the alternatives and the importance of the criteria are quantified with the use of an interval scale. From among the *cardinal methods*, Cross (2000) describes the *Weighting Objective Method* as to be used for evaluating the utility values of alternative design proposals on the basis of performance against differentially weighted objectives.

1. The design objectives are listed, including technical and economic factors, user and safety requirements. During the process, objectives may need to be modified or refined.
2. The list of objectives is rank-ordered, using a *comparison chart*, where the objectives are paired in intersecting boxes and the more important ones scored. The row totals will yield the rank order on an ordinal scale.
3. Relative weighting are assigned to the objectives, which are then transferred to an interval scale where they are positioned again on a scale of for example, 1 to 10, or 1 to 100.
4. Performance parameters or utility scores are established for each of the objectives, converting them into parameters that can be measured or estimated. For parameters that cannot be measured in a quantifiable way, utility scores may be assigned on a points scale. The simplest scale has five points, grading from for example *far below average*, to *average*, to *far above average*.
5. The relative utility values of the alternative designs are calculated and compared. Evaluation is best carried out with the team members, through mutual discussions and comparisons.

A great deal of design work in practice is for the improvement or modifying of an existing product, rather than the creation of an entirely new one. Also, a solution is selected, assuming that the purchaser will find its value worth, and the producer its cost worth. The *Value Engineering Method*, as Cross (2000) explains, aims to increase the value of a product to its purchaser while reducing the cost to the producer.

1. The separate components of the product are listed, the function of each component is identified. This may be through disassembling the product, or working on its drawings.
2. The values of the identified functions are determined on the basis of the customers' opinions.
3. The costs of the components are determined.
4. Ways of reducing cost without reducing value, or of adding value without adding cost are searched. A checklist of cost-reduction suggests the following:

   Is it possible to *eliminate* any function, therefore any component?

   Is it possible to *reduce* the number of components, or to combine several into one?

   Is it possible to *simplify* the function components or overall shape?

   Is it possible to *modify* the use of material, or method of manufacture with cheaper alternatives?

   Is it possible to *standardise* parts, dimensions or components?

The attributes that may contribute to the quality or value of products may be; utility, reliability, safety, simple infrequent or no maintenance requirements, a long life-time for non-disposable products, little or no pollution including unpleasant by-products such as noise and heat.

5. The alternatives are evaluated and improvements to be made are selected.

Pugh (1996) groups evaluative methods as *qualitative*, *quantitative* and *combination. Qualitative methods* are used for creative alternatives; *quantitative methods* are analytical. The selection of the best design concept, to be operated on to produce the optimum design, requires proceeding from the evaluation of alternative approaches to meet the specification. At the point where one or more are selected through a qualitative method, quantitative mathematical methods can be applied rationally to refine and enhance the chosen concept. Earlier selection mistakes may be prevented if evaluation at the intangible end of the spectrum takes place first, rather than mathematical optimisation at the tangible end. Pugh (1996: 181) stresses that there may not be such a thing as the optimum design in the mathematical sense, unless the optimisation criteria are artificially constrained to suit the mathematics, 'the successful design is always the sum of the best compromises'.

The main point of departure in the design activity being the establishment of a concept, Pugh (1996) devised the *Method of Concept Selection* to minimise conceptual vulnerability. This method may also be used in stages where design decisions are given, and aims at eliminating the constraints imposed upon creativity to obtain new or improved products.

Phase I. *Procedure for minimising conceptual vulnerability.*

1. A number of embryonic solutions, or concepts are established in sketch, all at the same level of detail.
2. A matrix is prepared for concept comparison and evaluation (*Figure 3.4.1.*).
3. All the concepts in the matrix are visualised.
4. The validity of comparison is ensured through making them all to the same basis and at the same generic level.
5. Criteria against which the concepts will be evaluated are chosen. Based upon detailed requirements of product specification, the criteria must be unambiguous and understood by all evaluators.
6. A *datum* is chosen to compare all other concepts with. A design or designs already existing in the area may be useful as a datum choice.
7. Each concept or criterion is considered against the datum. A plus sign (+) is used for comparisons better than, less than, less prone to, easier than. A minus sign (-) is used for comparisons worse than, more expensive than, more difficult to develop than, more complex than, more prone to, harder than, etc. The letter S is used for situations where the concept is found to be the same as the datum.
8. These comparisons are marked on the matrix. Score patterns in terms of the number of pluses, minuses and S's are established.

9. Each individual score is assessed. If certain concepts show exceptionally high scores, the matrix is rerun with the strengths giving the high results, removed. This may be done several times. If the high scores keep appearing, these concepts may be the ones to choose to be developed.
10. If there are not any persisting concepts, the datum should be changed and the assessment redone.
11. If one particular concept persists, the datum is changed and the matrix rerun. If the result does not change, the strong concept should be used as the datum to compare with the other concepts. The matrix is rerun and the results assessed.

For additional concepts that may arise, the process is repeated. The matrix for complex concepts may take long to run. Pugh suggests that the method gives insight into the specification requirements; a greater understanding of the problem and of the possible solutions; an understanding of how the proposed solutions may interact thus suggesting additional solutions; and an understanding of why a concept is stronger or weaker compared to the others.

	CONCEPT										
CRITERIA	1	2	3	4	5	6	7	8	9	10	11
A	+	-	+	-	+	-	**D**	-	+	+	+
B	+	S	+	S	-	-		+	-	+	-
C	-	+	-	-	S	S	**A**	+	S	-	-
D	-	+	+	-	S	+		S	-	-	S
E	+	-	+	-	S	+	**T**	S	+	+	+
F	-	-	S	+	+	-		+	-	+	S
Σ +	3	2	4	1	2	2	**U**	3	2	4	2
Σ -	3	3	1	4	1	3		1	3	2	2
Σ **S**	0	1	1	1	3	1	**M**	2	1	0	2

Figure 3.4.1. Evaluation Matrix (Table from Pugh, 1996: 170).

Phase II.

In the second phase, the strongest concepts are worked on to a higher level and in more detail. A matrix is formed with the enhanced concepts and expanded criteria. The outcome may confirm the results of Phase I, or reveal a reordered set of concepts.

The *Enhanced Quality Function Deployment* (*EQFD*) suggested by Pugh (1996) is an enhanced version of QFD, described earlier in Section 3.1., and used for complex systems which must be considered at several levels (*Figure 3.4.2.*), described as: *total system architecture TSA*, *subsystem SS*, and *component* or *piece-part PP.* Concept selection is carried out at each level, from TSA to SS, to PP. A TSA is selected, and a *total system design matrix* is prepared. Decisions are made at the level of the total system and the *total system expectations* are deployed into *subsystem expectations*, which are then used to select the concept at the level of the subsystem. Concept selection is done using the *Pugh Concept Selection Process*, with the criteria (row headings) taken from the columns of the *total system design matrix.*

Based on the selected concepts, the *subsystem design matrix* is prepared. Design decisions are made at this level, and are then deployed *from subsystem expectations* to *piece-part expectations*. The rows that are input to the *subsystem design matrix* are the columns from the *total system design matrix*. The columns in the *subsystem design matrix* are *piece-part expectations*, which are next used to perform concept selection for the piece-parts. The *piece-part expectations* are used as criteria (row headings) in the *Pugh Concept Selection Process*, and the detailed design decisions are made in the *piece-part design matrix*.

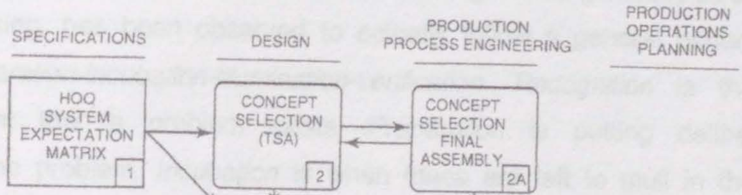


Figure 3.4.2. The basic process of Enhanced Quality Function Deployment (Figure from Pugh, 1996: 188).

The evaluation and decision making methods can thus be employed at any phase of the design process, usually through the use of matrix charts. The methods described in this section are selected from among those found highly reliable, and the results can be accepted as almost entirely factual, particularly when combined with the experience and sound judgement of the members of the design team.

3.5. CREATIVITY AS A FACTOR ALONGSIDE DESIGN METHODS

All along the employment of design methods, there stands the factor of creativity, a most welcome input throughout. Creativity has been considered as an attribute of design, and an asset that elevates the design product, and the nature of creativity has always been a source of interest. How can creativity be explained, and how can it be further encouraged? The sudden novel insight that the designer may bring on a design proposal has been a subject of study and as mentioned in *Section 2.1.*, this 'creative leap' has been 'characterised as a sudden perception of a completely new perspective on the situation as previously understood' (Cross, 1997: 427). This definition is based on Koestler's *model of bi-sociation* discussing creative insight. Cross argues that in explaining the creative leap, there may not be an unexpected dislocation of the solution space, but only an insight to a new part of it, where a different and appropriate concept may be found.

The sudden emergence of what may be considered a bright idea, generally as a result of a period of creative thinking, has been observed to actually follow a general pattern (Cross, 1997): *recognition-preparation-incubation-illumination-verification*. *Recognition* is the realisation or acknowledgement that a problem exists. *Preparation* is putting deliberate effort into understanding the problem. *Incubation* is when ideas are left to mull in the mind, with the subconscious getting into activity. *Illumination* is the often quite sudden understanding of a main idea. *Verification* is developing the idea and testing it. In summary, this process can be stated as *work-relaxation-work*. Janis and Mann (1977; cited in Pahl & Beitz, 1996) suggest that mild, bearable stress also plays a positive role in triggering creativity.

Designing is a continuous search for solutions (Pahl & Beitz, 1996), and the way the designer thinks is a major concern for devising design methods. Most design tasks demand problem-solving activity from the designer's part; the majority of methods and techniques offered for creativity are based on problem-solving. In solving problems, there is need of a certain amount of factual knowledge, transferred into memory (*epistemic structure*). There is need also of procedures, to effectively find solutions (*heuristic structure* of thought). Memory uses these thought structures to analyse relationships to create new ones and to store them, while solving problems. These relationships, such as concrete-abstract, whole-part, space-time, are important for the designer, who conceptualises and manipulates 3-D forms.

While discussing creative problem solving, Hekkert (1997) stresses the importance of the way a problem is formulated, and of the importance of the quality of and the time devoted to research carried out prior to the design activity. Besides relevant information, it is argued that creative persons may also attend to irrelevant information that may help in triggering novel ideas. For instance, Hekkert believes that designers must be able to attend all kinds of facts and take their time in doing so. The more experience trained problem solvers gain, the more they may generate novel solutions. This is related to the knowledge and information that they have at their disposal, and to the time they have spent on discriminating among the various types of information and on building up interrelations.

Theories on the creative act were highly discussed in the 1960s, in the hope to understand how designers think. The *Determinist View* suggested that thinking is merely a matter of logic, concerned with the progressive alternation of hypothesis and test. This view acted as the basis of the scientific method, also excluding the unreliability of the human factor from the design process.

The *Associationist View* (of stimulus and response) suggests that when they first arise, ideas are associated in the mind. The creative act consists of drawing on these associations, in rapid sequences of trials and errors. The *Gestalt Theory* is based on the idea of *schema*, first conceived by Head, and further developed by Bartlett in 1961 (cited in Broadbent, 1966). Schemata are arrangements of past responses to stimuli within the brain; memory changes result from interactions of schemata with each other, and with new external stimuli. The schemata are thus organised according to a person's instincts, interests and ideas. According to the Gestalt Theory, a problem consists of an incomplete structure; and to solve it, one must understand the relationships between the parts of this structure. To close the gaps, one will draw relevant material from one's previous experiences that are stored in the schemata within the brain. Bartlett suggests that imagination consists of free constructions drawn from one's schemata, and any technique that encourages creative activity will be based on enhancing such free constructions.

Parts of external information are selected for attention, to be recorded and to be reformulated in complex ways, to be later used for thinking (Neisser,1967; cited in Lawson, 2000). Reasoning and imagining are considered as the most important modes of thinking for the designer (Lawson, 2000). Reasoning is considered purposive, and directed towards a particular conclusion, using logic, problem-solving and concept formation. Imagining on the other hand, makes an individual draw from own experience and combines material in a relatively unstructured manner. Murphy (1947; cited in Lawson, 2000) suggests that mental processes are bipolar; they are influenced by both the external world and inner personal needs. Whereas problem-solving requires more attention to the demands of the external world, imaginative thinking used in creativity and artistic skills, is more towards satisfying inner needs through cognitive activity. Designers must do both kinds of thinking in a balanced way. It is doubtless that this balanced creative way of approach will enhance a design process conducted according to a selected design method, and will help soften the often criticised rigidity that the application of a method may ensue.

3.6. CRITICISMS ON DESIGN METHODS

Jones (1984a: 10) defines method as 'primarily a means of resolving a conflict that exists between logical analysis and creative thought', and thinks that design methods (1984a: 9) were necessary 'to reduce the amount of design error, and to make possible more imaginative and advanced designs', particularly where there are large quantities of design information available; for the design team to be free of routine design work and concentrate on development; and to achieve designs that are different from existing ones. Archer (1984a: 77-78) also believed that,

> 'One major contribution that systematic methods of designing might make, especially when supported by mechanical aids, is to reduce the dull, imagination-suppressing chores which the design now has to undertake, releasing him to devote more of his time to equipping himself for his crucial task – that of making the *creative leap*'.

Despite the extensive efforts lavished on developing methods, offering them for the use of designers and engineers, and advocating their positive effects on the design process, design methods are highly criticised for a number of reasons. The methods, it is argued, are not well understood, and consequently not used as widely as they should be, because of the increasing gap between practice and design research. Pugh (1996) argues that many of these methods are not easily applicable and do not produce results that are much different from results that would have been obtained without their use. Christopher Alexander (cited in Broadbent, 1984: 339) said in 1971, that the 'design methods as originally set up actually destroy the frame of mind the designer needs to be in (...)', when designing. Archer (1984b: 349) later stated:

> 'The design activity is commutative, the designer's attention oscillating between the emerging requirement ideas and the developing provision ideas, as he illuminates obscurity on both sides and reduces misfit between them. One of the features of the early theories of design methods that really disenchanted many practising designers was their directionality and causality and separation of analysis from synthesis, all of which was preceived by the designers as being unnatural'.

As may be understood, criticsms were mainly on methods not being suitable to the *designerly ways* of conducting the act of design. Designing is a creative act, and though guidance is essential in this process, the nature of the act requires that the designer is provided with the freedom and space to express his own appraoch to the problem. As seen in examples of methods discussed particularly in *Sections 3.1., 3.2.,* and *3.4.,* many methods rely on random associations, and systematic and rapid eliminations of alternatives, hardly allowing time and consideration to base decisions on sound problem- and situation-relevant judgements. Methods interpreting creativity as randomised associations generated through coincidental and uncontrolled factors, are seen as particularly dangerous as they may produce questionable results. The other more systematic methods seem to offer sequential actions based on sound decisions, yet seem not to be generalisable to all design problems.

The act of design cannot be a totally generalisable process. Anders (2000) argues that the design act carried out by the art-based disciplines such as architecture, graphics, fashion, industrial and interior design, require different design processes than the engineering-based disciplines. Joseph (1996) is another who can no longer agree on the universality of a systematic design process. He discusses the necessity of art-based designers approaching design problems in their own mechanical terms; and exploring the strengths and limitations through the guidance of design strategies. Lawson (2000) believes that the design process is *ideational*, rather than experimental; and therefore there cannot be established paths to a solution.

Also, selecting the appropriate method and its employment requires experience. Pugh (1996) argues that offering methods to those who do not know how to use them, does not make designers out of them. Each design is different; a method may help the improvement of a design, it may also hamper it. For instance fragmenting the design process with the suggested methods, also fragments the ability of the designer or design team to keep in control of the design situation as a whole, particularly during the stage of transformation. New methods have also been criticised from the point of view that, for large-scale problems of system development in particular, they do not increase the possibility of identifying critical objectives and sub-problems that have to be determined and investigated in the early stages of the process, for a successful convergence to take place. They are seen as inhibiting creativity or slowing down the design process; the short term benefits of employing methods seem to be absent; and the experience and knowledge of designers are considered much more useful (Albers, 1999; Gouvinas & Corbett, 1999; cited in Restrepo *et al.*, 1999). If we want to take control of the consequences of man-made evolution rather than being controlled by them, it has been suggested that methodologies must reflect issues related to persons who give decisions on design situations and to those affected by them. Methodologies must be a basis of 'conversation', as Jones (1980: 73) argues, that bridge the gap between past and future, without limiting the variety of possibilities of the future; and that integrate social changes with technical changes.

Yet, methods were born from practice (Restrepo *et al.*, 1999), and appear to tell the history of a process that supports design practice. The efficiency and effectiveness that methods offer may be hidden in the misunderstanding that they have to be strictly followed. Born from experience themselves, their employment will also require an accumulation of reasoning and intuition from the designer's part, who will have to configure how to best make use of them. As Restrepo *et al.* (1999) point out, an interpretative approach will be necessary at a methodological level. An approach that is interpretative and clear as to the formulation of the design procedure will also allow for and support the creativity and intuition of the designer. The choice of appropriate methodology, enhanced by the designer's creative thinking and interpretative approach in employing the methods, can lead the design process into the right path towards obtaining solutions that answer all the numerous demands that are weighted upon them. Otherwise, methods may remain as troublesome and time-consuming rigid techniques, generating numerous alternatives without much concern given on them, or may remain out of context to the problem in hand.

Needs and requirements for design problems, and the way design processes are carried out may change with time, progress in technology, transition of social values, economic and ecological considerations. Certain design methods, with those changes, may lose their relevance. All the same, the need for design problems to follow a structured guidance, a framework, remains; in fact, considering the social implications of the products that are offered to the market, this need is today perhaps even further emphasised. The following *Chapter 4.*, recognising the standing need for the organisational role of employing methodology, will study phase models offered as methodological structures for a design process to follow in its entirety, as an alternative to a segmented design process employing different methods at the different stages; or rigid application of one strategy regardless of the varying needs throughout the process.

4. EMPLOYING DESIGN METHODOLOGY AND PHASE MODELS IN THE DESIGN PROCESS

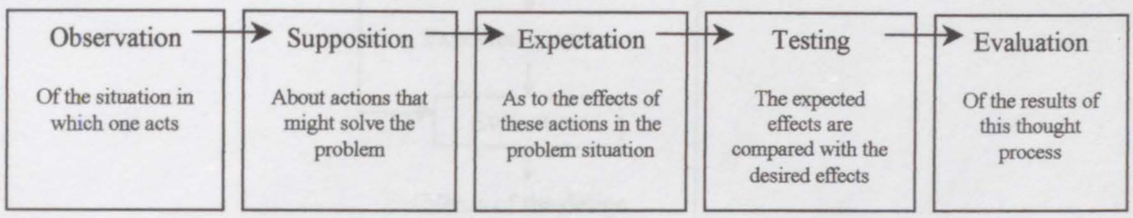
The study of the emergence and evolution, and the comparative discussion of design methods in the previous chapters has brought forth the fact that the design process may be structured into a sequence of methodised and procedurised activities, in other words, that a methodology may be employed in order to conduct the design process towards a solution that can be relied upon. Roozenburg and Eekels (1995) bring a clear understanding to the notion of design methodology, as the science of methods that can be applied in designing, in the sense that it studies methods, describes, explains and valuates them. Apart from being a field of study and research, design methodology is also a body of methods, procedures, working concepts or rules.

The aim of design methodology is to provide conceptual tools for designers with which to organise the design process. These tools as mentioned by Roozenburg and Eekels (1995) are: models of the structure of design and development processes, methods, and concepts. Design methodology produces a system of concepts and terminology for the thinking, acting and communication of the different contributors in the design process. Bunge (1966; cited in Roozenburg & Eekels, 1995) explains that in these acts, *operative knowledge* and *substantial knowledge* take part. *Operative knowledge* is concerned with action itself, within the design context, and *practical experience* and *formal knowledge* (such as logic and maths) are its most important sources. Knowledge on the process will not be enough for the designer, *substantial knowledge* about the composition and functioning of all objects and the systems they belong to, is also necessary. This is obtained through applied sciences such as technology, behavioural sciences and biology, and can be transformed into rules and methods for designing. Some methods based on substantial knowledge used in the design process are: methods for choosing materials, predicting life service, reliability and costs, forecasting methods from economic psychology and marketing.

4.1. MODELS FOR THE DESIGN PROCESS

Methodology suggests the methods that may be applied to different phases of the process that form the structure or the model of the design process. How these phases are structured also depends on the working mode or strategies of persons employing the models. The modes of working may be *step-oriented* and *function-oriented* as Fricke (1993; cited in von der Weth, 1999) suggests. The *function-oriented strategy* deals with sub-problems in the order of importance, from the clarification of the task to the layout drawing. As a result of this sequential work, the solution of the sub-function has to be adjusted to other sub-functions already treated. This may be a time-saving approach as it treats sub-areas immediately, although it may also complicate the optimisation of a solution. The *step-oriented strategy* follows the design steps proposed by Pahl and Beitz (1996), who suggest that designers make flexible use of methods to support the design steps, thus adjusting the emphasis on particular steps, depending on the task in hand (von der Weth, 1999). Pahl and Beitz (1996: 61) call these models *procedural plans*, which are 'operational guidelines for action, based on the pattern of technical product development and the logic of stepwise problem solving'. As operational guidelines blend with individual thinking processes, models become a set of individual planning, acting and controlling of activities based on general procedures, specific problem situations and individual experience.

Roozenburg and Eekels (1995) indicate that there are three types of models emphasising different aspects of designing. The first model treats design as a type of *problem-solving*, with the activities carried out in cycles. De Groot (1969; cited in Roozenburg & Eekels, 1995) calls this the empirical cycle:



Characteristic of this cycle is that, the trial-and-error process plays an important role. Solutions are tentatively chosen and tried out in the mind, or with the use of a model, the effects are evaluated and correct measures are taken. The problem and the solution develop like a spiral: the cycle is repeated, each new cycle being influenced by the experience of the previous one. De Groot calls this, *the empirical cycle as reflected* and argues that the empirical cycle is a logically indispensable thought model, used in all sorts of purposeful behaviour such as learning, problem-solving, creative thinking, etc.

The second type of model is the *basic design cycle* (*Figure 4.1.1.*), which considers design to be a trial-and-error process that consists of a sequence of empirical cycles, in search of a means effective in realising the goal. The design act requires that the steps in the model are carried out in at least one cycle. The knowledge of the problem definition and the solution increases spirally. Roozenburg and Eekels (1995) find this model useful in classifying rules and methods of designing (see *Table 3.1.*).

The basic design cycle is considered as an indispensable structural unit (Roozenburg & Eekels, 1995). This descriptive cycle becomes a norm for effective designing, therefore it can also be considered to be a prescriptive model. However, as the cycle is abstract and too general, it will remain insufficient for the purposeful structuring of design projects in practice. The basic design cycle may be worked out into a *phase model,* a third type of model, where the process will be divided into groups of related activities. With the spiral-like development of the process, each activity leads to a certain stage of development of a design, where elaboration of proposed solutions take place. The end of each phase will be a decision point, and each phase will require regular evaluation and checking.

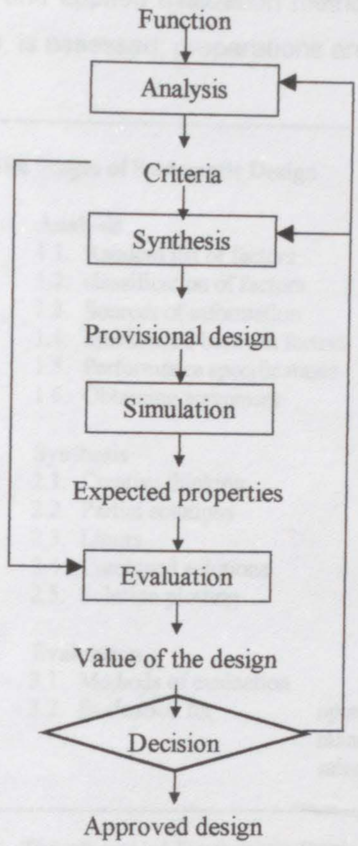


Figure 4.1.1. The Basic Design Cycle (Roozenburg & Eekels, 1995: 88).

4.2. PHASE MODELS FOR STRUCTURING THE DESIGN PROCESS

Phase models of design processes have been developed particularly in engineering design from the 1960s on. Four models based around the phases of *analysis*, *synthesis* and *evaluation* despite minor variations will here be discussed, to analyse the way the design process is structured into phase models. The first is a basic guideline described by Jones (1984a) as *Systematic Design*, where the stages of *analysis*, *synthesis* and *evaluation* are composed of steps of actions to be taken (*Figure 4.2.1.*). To this process can be incorporated different methods in order to complete the steps, selected according to the requirements of the design task in hand. The designer employing this procedure may determine his own design strategy by employing the suitable methods, as discussed in *Chapter 2*..

Jones (1984) envisages in this procedure that in the *analysis* stage, in order to understand the problem in hand, a list of factors is prepared, and the factors are classified according to the order of importance. The relevant sources of information are investigated, and the performance specifications for the solution are determined, to be presented to the client or manufacturer, to settle an agreement. In the stage of *synthesis*, through acts of creative thinking, the initial design stage takes place, alternative incomplete solutions are offered. The limits and constraints to the solutions are determined; the solutions are reconsidered, and some are combined, and the suitable solutions are plotted. In the *evaluation* stage, the chosen alternative solutions are evaluated through selected and applied evaluation methods; how the end product will operate within time and among users, is assessed; preparations are made for the manufacture and sales.

The Stages of Systematic Design

1. **Analysis**
   - 1.1. Random list of factors
   - 1.2. classification of factors
   - 1.3. Sources of information
   - 1.4. Interactions between factors
   - 1.5. Performance specifications
   - 1.6. Obtaining agreement

2. **Synthesis**
   - 2.1. Creative thinking
   - 2.2. Partial solutions
   - 2.3. Limits
   - 2.4. Combined solutions
   - 2.5. Solution plotting

3. **Evaluation**
   - 3.1. Methods of evaluation
   - 3.2. Evaluation for operation / manufacture / sales

Figure 4.2.1. The stages of Systematic Design (Jones, 1984: 11).

The following process, *Structured Planning*, is developed at the Design Processes Laboratory at the Institute of Design at the IIT, in collaboration with engineers and designers. This process employs methodology influenced by *Alexander's Method of Determining Components*, discussed in *Section 2.7.*, and has specific computer programs developed as aids to its application. Owen (1986) defines *Structured Planning* as a process for finding and structuring the information necessary for design and planning activities, developed particularly for dealing with complexity in design. The procedure defines a highly methodised process that relies on clear understanding of the problem, the requirements from the design, and the system into which the design will fit. The stages of the process are as follows:

I. Defining A Project: The process begins with a *project statement*, using simple and direct function-oriented phraseology to help clarify points of interest and recognise limitations. The project statement involves *defining statements*, which are additional descriptions of issues to be addressed, suggesting the direction of the project. Owen (1986) describes three kinds of *defining statements*. *Constraints* are the strongest, stating what *must* or *must not* be done. *Objectives* are less forceful, bearing in the statements, the word *should*. *Directives* are goals that are desirable, if not urgent, expressing a bias, or a statement of style, with descriptions using the word *ought to*. The project statement is given in a 3-part format:

Issue: One or two words establishing the subject of the statement.

Position: A sentence or two describing the position to be taken on the issue.

Background: Discussions in paragraph form to explain the reasons why the position was selected, and why others were not.

II. Developing Information: 'All things designed exist in time', in relation to users operating in different ways, 'for different modes of existence (Owen, 1986: 3)'. For effective design, these *modes*, the *activities* that occur in them, and *functions* that the system must perform, must be recognised.

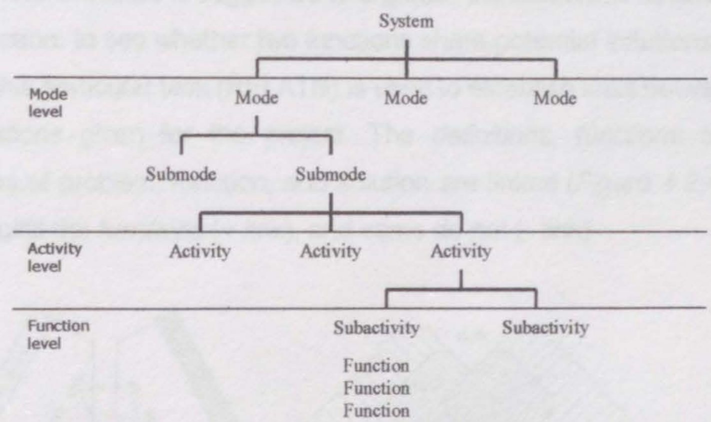


Figure 4.2.2. A three level model to break down SYSTEM ACTIONS to find the primary FUNCTIONS the system must perform through all its MODES of behaviour (Owen, 1986 : 3).

To begin with, the *modes* which systems pass through, are defined (*Figure 4.2.2.*). The purposeful actions taken by the users and system in an environmental setting are defined in the activity, through *activity analysis*. The *functions* involved in this interaction are identified. *Insight* is necessary for *action analysis*, to foresee what may happen when the *functions* are performed. These *insights* are documented as *design factors*, to become part of qualitative information, along with the *functions*. As *insights* are developed, *ideas* are sought as to how to use these *insights*, but these are not *final solutions*. *Action analysis* (*Figure 4.2.3.*) is an investigation of: Users in relation to System Components; System Functions in relation to Design Factors; and User Functions in relation to Design Factors.

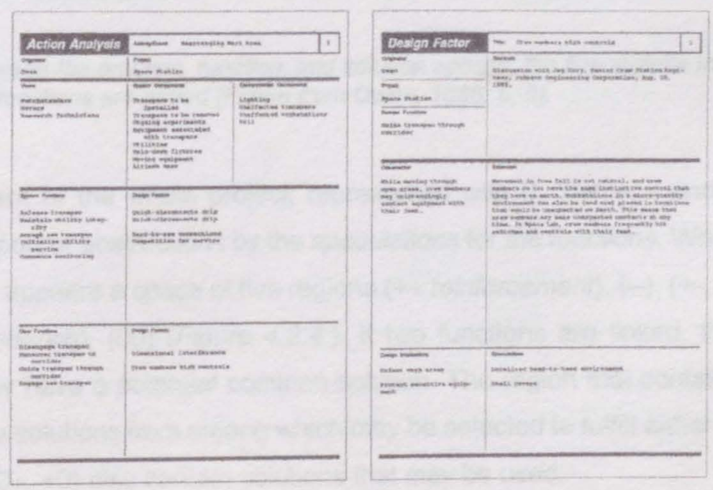


Figure 4.2.3. The Action Analysis and Design Factor Documents (Figure from Owen, 1986: 5).

The *Design Factor Document* (*Figure 4.2.3.*) involves information about the problem and information about what may be done about it. Sections of the document, that are to be documented on the computer involve statements on:

Observation (Related to the problem): A sentence on *insight* regarding a function.

Extension (Related to the problem): Explanatory material developing this information.

Design Implications (Related to the solutions): Generalised suggestions, expressing the implications of this information on the design, prescribing a design strategy.

Speculations (Related to the solutions): Speculative solutions determining interaction among functions.

III. Organising Functions: Alexander's Method is suggested to organise the numerous functions for a complicated concept organisation: to see whether two functions share potential solutions. A computer program developed for this particular task (RELATN) is used to establish links between functions based on the *speculations* given for the project. The *definitions*, *functions* and *speculations* in the abstract spaces of problem, function, and solution are linked (*Figure 4.2.4.*). Some of the *speculations* help to fulfill the *functions* (+ link), and some do not (- link).

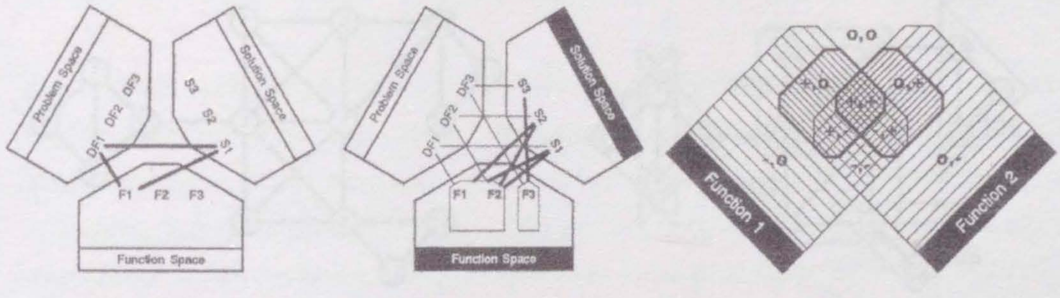


Figure 4.2.4. Establishing links between the problem, function, and solution spaces; the five regions that appear when two functions are paired (Figure from Owen, 1986: 8, 9).

Some *speculations* are the concern of the whole project, represented with 0. The +, - and 0 values in each region indicate support or obstructions by the *speculations* for the *functions*. When the two *functions* are paired, there appears a space of five regions (++ *reinforcement*), (--), (+-, -+ *conflict*), (0-, -0), (0+, +0 *independence*), (00) (*Figure 4.2.4.*). If two functions are linked, this means they interact, therefore they have a potential common solution. The region that contains the positive *speculations* are all the solutions from among which may be selected to fulfill either of the two *functions*. The regions of (0+, +0) also contain solutions that may be used.

The measure for interaction is the ratio of the number of *reinforcing* and *conflicting speculations*, plus the number of *independent speculations*. The RELATN program calculates this interaction, and its proportion to the number of *speculations* in the common regions of *reinforcement* and *conflict*. Secondly *speculations* are weighted in order to reflect the likelihood that

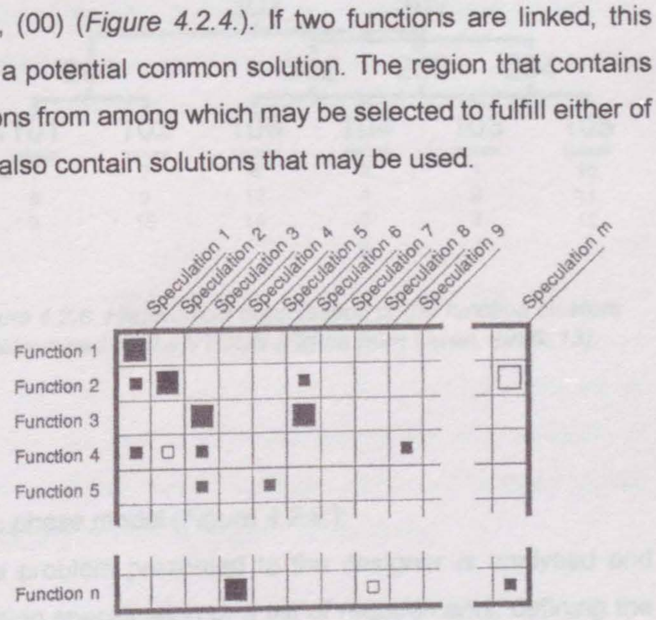


Figure 4.2.5. Assessment of speculations *for their potential of support (solid squares) or obstruction (hollow squares) of* functions, *in order to determine the interaction among the functional pairings (Figure from Owen, 1986: 10).*

a *speculation* could be used in the final solution, which increases or reduces its effect on the amount of interaction. Then a weighting chart is used to determine which *functions* have more *speculations* to be of concern, compared to others (*Figure 4.2.5.*).

IV. Structuring The Information: This information is used to pair functions that interact. After the RELATN program establishes paths between the interacting *functions (Figure 4.2.6.)*, the VTCON program finds the clusters of *functions* algorithmically. The clusters are the primary groupings of *functions*, and an organisation of these helps the designer choose the *functions* that are of direct concern (*Figure 4.2.7.*). As *functions* may be linked to other clusters, the program reorganises clusters in order to display a hierarchy until the link is recomposed into a final cluster (*Figure 4.2.8.*).

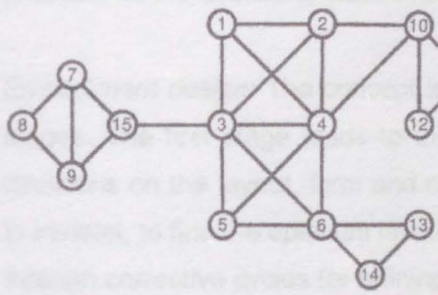


Figure 4.2.6. Links determined by the RELATN program (Figure from Owen, 1986: 11).

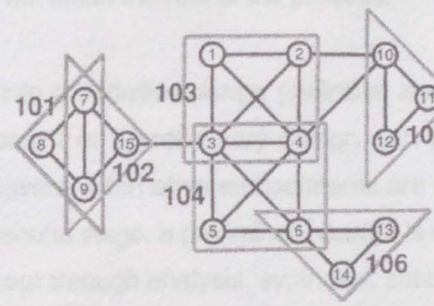


Figure 4.2.7. Clusters determined by the VTCON program (Figure from Owen, 1986: 12).

V: Using The Information: The final cluster and the related information are used to be developed into the final design. Owen (1984: 13) argues that, rather than breaking down the design process into *analysis-synthesis-evaluation*, that follow each other, this model blends these phases; 'ideas are synthesised and evaluated as they take form'.

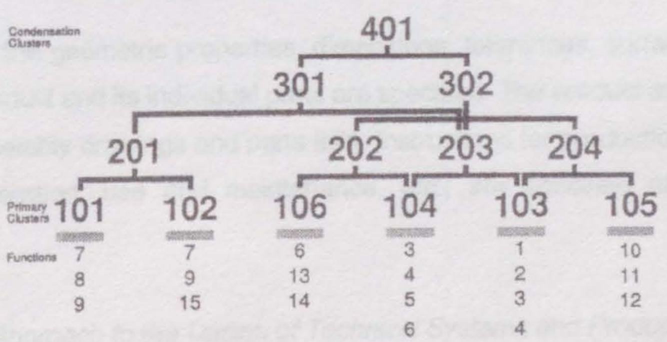


Figure 4.2.8. Hierarchical organisation of the function clusters determined by the VTCON (Figure from Owen, 1986: 13).

Another example is Pahl and Beitz' (1996) phase model (*Figure 4.2.9.*):

- *Planning and clarifying the task:* The problem presented to the designer is analysed and information is collected towards a design specification or a list of requirements, defining the functions and properties required for the product. Constraints such as standards and time limits are determined. As work progresses in further phases, the design team's conception of the problem may change, and new information may become available. Therefore the design specification is regularly checked; this is represented in the phase model with feedback loops.

- *Conceptual design:* The phase begins with determining the overall function and the interrelationships of the sub-functions (*function structure*) according to which, the *working principles* (*solution principles*) are determined for the sub-problems; these are integrated into the overall solutions, called by Pahl and Beitz (1996) *solution concepts*, and *schemes* by French (1985; cited in Roozenburg & Eekels, 1995). The choice for a principal solution does not only depend on technical criteria but also on use, appearance, production, costs, etc. The principal solution is worked up into *concept variants*, which partly show the embodiment of the principle. Conceptual design may be considered the most important phase of the process, as the decisions made in this phase will affect the rest of the process.

- *Embodiment design:* The concept is worked into a *definitive design* (*definitive layout*) in two stages. The first stage leads to the development of a preliminary design with provisional decisions on the layout, form and material. Several alternative embodiments are developed in parallel, to find the optimum layout. In the second stage, a preliminary design is elaborated through corrective cycles for refining the concept through analysis, synthesis, simulation and evaluation which alternate and complement each other; and major decisions on the layout and form are made, its functionality, use, appearance, consumer preference, reliability, manufacturability and cost are tested and assessed. Finally, the design is represented by scale drawings and preliminary parts lists.

- *Detail design:* In this final phase, the geometric properties, dimensions, tolerances, surface properties and materials of the product and its individual parts are specified. The product and its components are laid out in assembly drawings and parts lists. Instructions for production, assembly, testing, transport, operation, use and maintenance, etc., are specified and documented.

The *Guideline VDI 2221*[2] *Systematic Approach to the Design of Technical Systems and Products* is a more recent model as a general approach to design and is developed to be applicable to a variety of tasks, such as different branches of industry (*Figure 4.2.10.*). The model, which displays a similar layout to Pahl and Beitz's model discussed previously, is broken into seven stages, for particularly complex products to be realisable, with each stage producing a result. To assist the overall planning and management of the design process, individual stages may be combined into design phases, depending on the branch of industry or company.

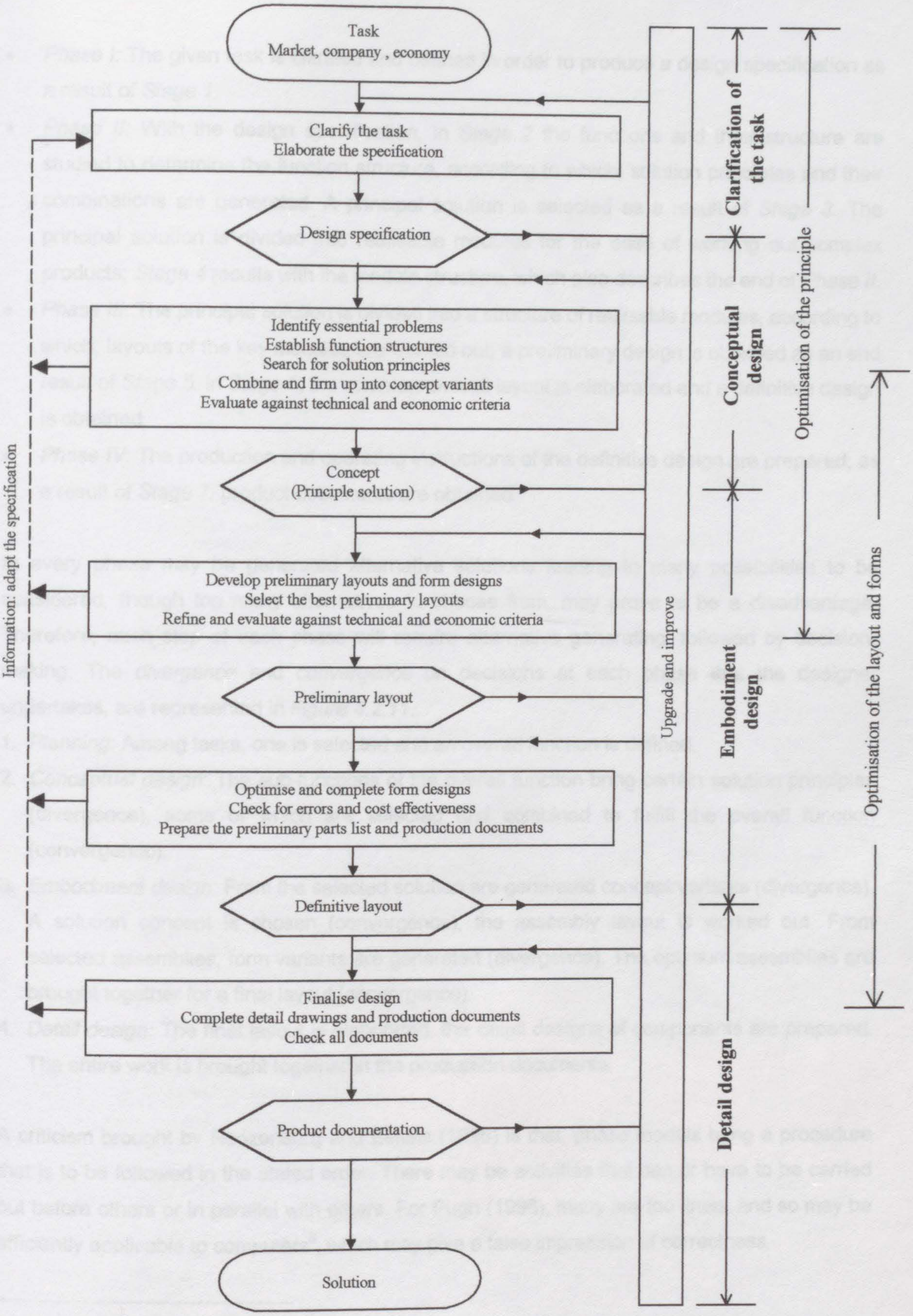


Figure 4.2.9. Steps of the planning and design process (Pahl & Beitz, 1996: 66; adapted version in Roozenburg & Eekels, 1995: 105).

[2] VDI Verein Deutscher Ingenieure / Society of German Engineers. The VDI 2221 Guideline was issued in 1985 under the leadership of Beitz.

- *Phase I:* The given task is clarified and defined in order to produce a design specification as a result of *Stage 1*.
- *Phase II:* With the design specification, in *Stage 2* the functions and their structure are studied to determine the function structure, according to which, solution principles and their combinations are generated. A principal solution is selected as a result of *Stage 3*. The principal solution is divided into realisable modules for the ease of working out complex products; *Stage 4* results with the module structure, which also describes the end of *Phase II*.
- *Phase III*: The principal solution is divided into a structure of realisable modules, according to which, layouts of the key modules are worked out; a preliminary design is obtained as an end result of *Stage 5*. In *Stage 6*, the complete overall layout is elaborated and a definitive design is obtained.
- *Phase IV*: The production and operating instructions of the definitive design are prepared; as a result of *Stage 7*, product documents are obtained.

In every phase may be generated alternative solutions leading to many possibilities to be considered, though too many alternatives to choose from, may prove to be a disadvantage. Therefore, each step of each phase will require alternative generating, followed by decision-making. The *divergence* and *convergence* on decisions at each phase that the designer undertakes, are represented in *Figure 4.2.11.*.

1. *Planning:* Among tasks, one is selected and an overall function is defined.
2. *Conceptual design:* The sub-functions of the overall function bring certain solution principles (divergence), some of which are selected and combined to fulfill the overall function (convergence).
3. *Embodiment design:* From the selected solution are generated concept variants (divergence). A solution concept is chosen (convergence), the assembly layout is worked out. From selected assemblies, form variants are generated (divergence). The optimum assemblies are brought together for a final layout (convergence).
4. *Detail design:* The final layout is elaborated, the detail designs of components are prepared. The entire work is brought together in the production documents.

A criticism brought by Roozenburg and Eekels (1995) is that, phase models bring a procedure that is to be followed in the stated order. There may be activities that can or have to be carried out before others or in parallel with others. For Pugh (1996), many are too linear and so may be efficiently applicable to computers[3], which may give a false impression of correctness.

[3] On the argument of using computers in processing design models, Pahl and Beitz (1996) suggest that design methodology should be compatible with electronic data processing; by making the design process computable, it is hoped to reduce workload, save time and prevent human error. This argument may be against the belief that computerising the design process will reduce the role of the designer even further. What Pahl and Beitz argue is that, to be able to compete with the other disciplines where computers are highly used and form a language common to the disciplines that use them, the design process must be able to be represented in a logical, sequential and transparent manner, to be able to share the same language. The main point of the argument is that, the intuition, experience or creativity of the designer may be even further emphasised when such systematic procedures offered by computers serve to increase the output and inventiveness of designers.

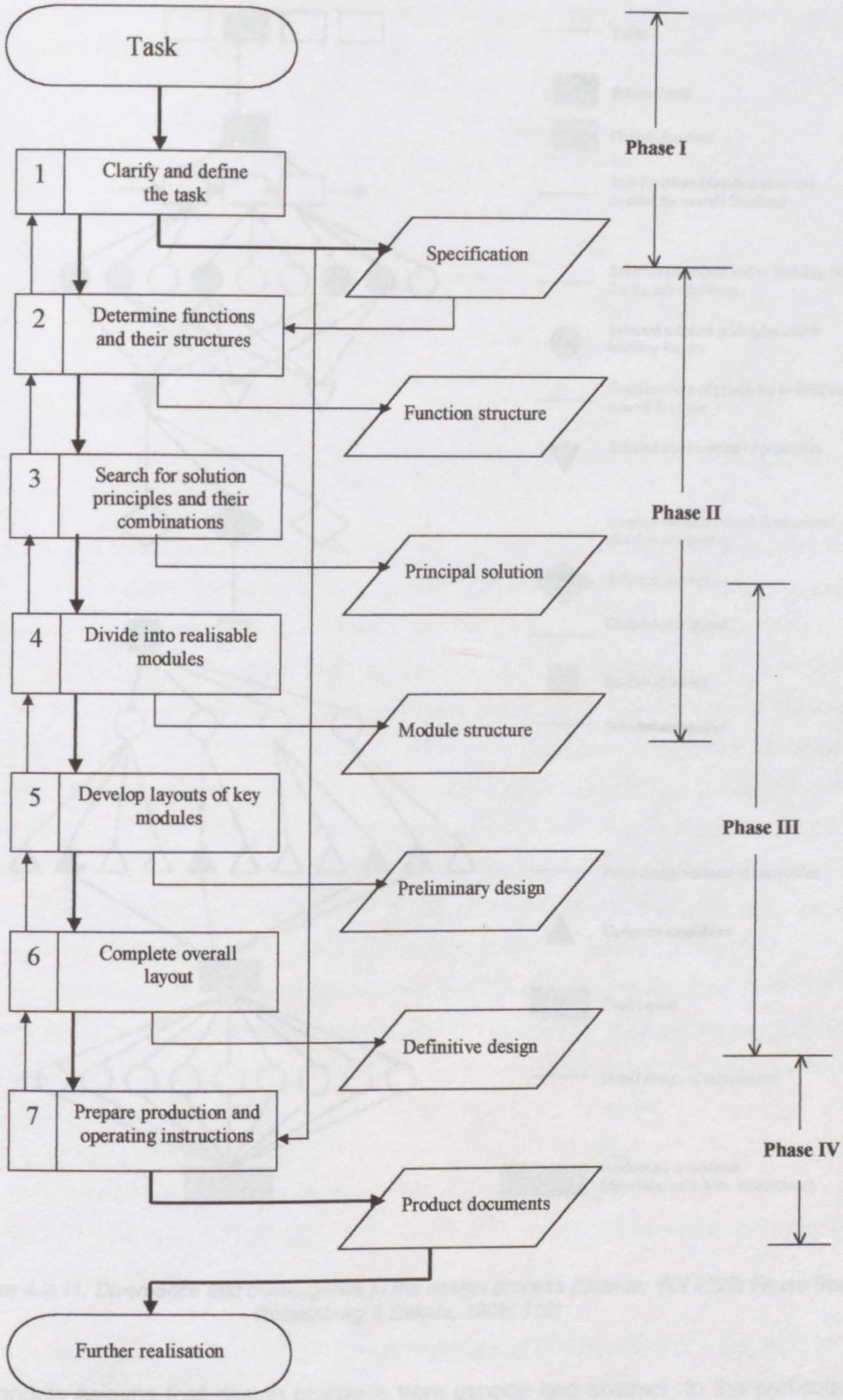


Figure 4.2.10. General approach to design according to VDI 2221 (Figure from Roozenburg & Eekels, 1995: 108).

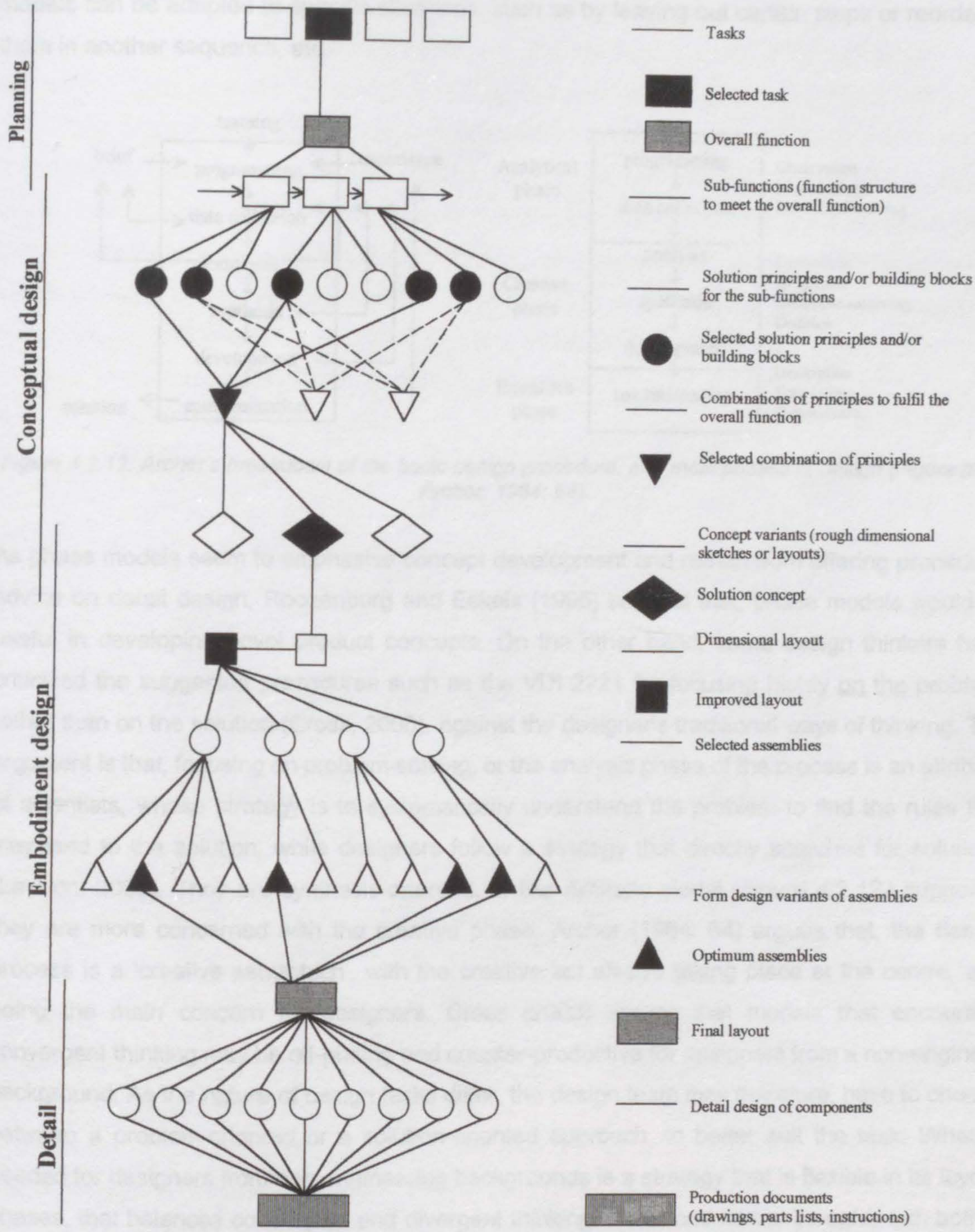


Figure 4.2.11. Divergence and convergence in the design process (Source: VDI 2222; Figure from Roozenburg & Eekels, 1995: 110).

Phase models assume that design proceeds from general and abstract, to the particular and concrete, which may not be how designers employing the model, work on a problem. Phase models are also devised on the assumption that complex problems should be split into sub-problems that have to be solved first and synthesised into the overall solution. This may not always be the case, as some problems may need to be solved in integrity. Pahl and Beitz (1996) bring a counter argument, stating that procedural plans, or models are not rigid prescriptions.

They are essentially sequential, as certain stages cannot precede others. Yet, these plans or models can be adapted to specific situations, such as by leaving out certain steps or reordering them in another sequence, etc.

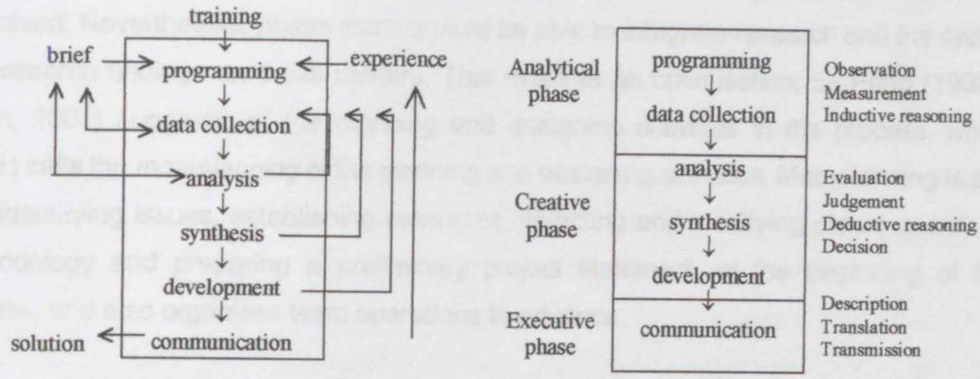


Figure 4.2.12. Archer's breakdown of the basic design procedure, and main phases of design (Figure from Archer, 1984: 64).

As phase models seem to emphasise concept development and refrain from offering procedural advice on detail design, Roozenburg and Eekels (1995) suggest that, phase models would be useful in developing novel product concepts. On the other hand, some design thinkers have criticised the suggested procedures such as the VDI 2221 for focusing highly on the problem, rather than on the solution (Cross, 2000), against the designer's traditional ways of thinking. The argument is that, focusing on problem-solving, or the analysis phase of the process is an attribute of scientists, whose strategy is to systematically understand the problem to find the rules that may lead to the solution, while designers follow a strategy that directly searches for solutions (Lawson, 2000). They are synthesis-oriented, or like Archer's model (*Figure 4.2.12.*) suggests, they are more concerned with the creative phase. Archer (1984: 64) argues that, the design process is a 'creative sandwhich', with the creative act always taking place at the centre, and being the main concern for designers. Cross (2000) argues that models that encourage convergent thinking may be off-putting and counter-productive for designers from a non-engineer background. As the nature of design tasks differ, the design team may therefore, have to choose between a problem-oriented or a solution-oriented approach, to better suit the task. What is needed for designers from non-engineering backgrounds is a strategy that is flexible in its layout phases, that balances convergent and divergent thinking, linear and lateral thought, with both a serialist and holistic approach. In other words, the process must thus foster the right kind of thinking at the right stage.

4.3. MODELS FOR THE DESIGN PROCESS REPRESENTED IN ITS TOTALITY EMBODYING PRODUCT PLANNING

Wright (1998) argues that diagrammatic representations of design models fail to represent the complexity of the design process within the commercial setting, particularly in relation to product design. As product innovation comprises more than product design and development, further methods and procedures have been necessary for the involvement of activities such as marketing research and planning, business investment, distribution, sales and after sales service, within the totality of the design process, as was briefly mentioned in the introduction to *Chapter 3*. As the scope of this thesis is concerned with the representation of a design activity in the procedural form of a design model, the business and marketing considerations will not be discussed. Nevertheless, phase models must be able to integrate research and the application of the research findings on these matters. This requires an optimisation, as Peng (1993; cited in Owen, 2001) suggests, of the planning and designing activities in the process, which Owen (2001) calls the *metaplanning* of the planning and designing activities. Metaplanning is concerned with identifying issues, establishing resources, selecting and modifying planning and designing methodology and preparing a preliminary project statement, at the beginning of the entire process, and also organises team operations in advance.

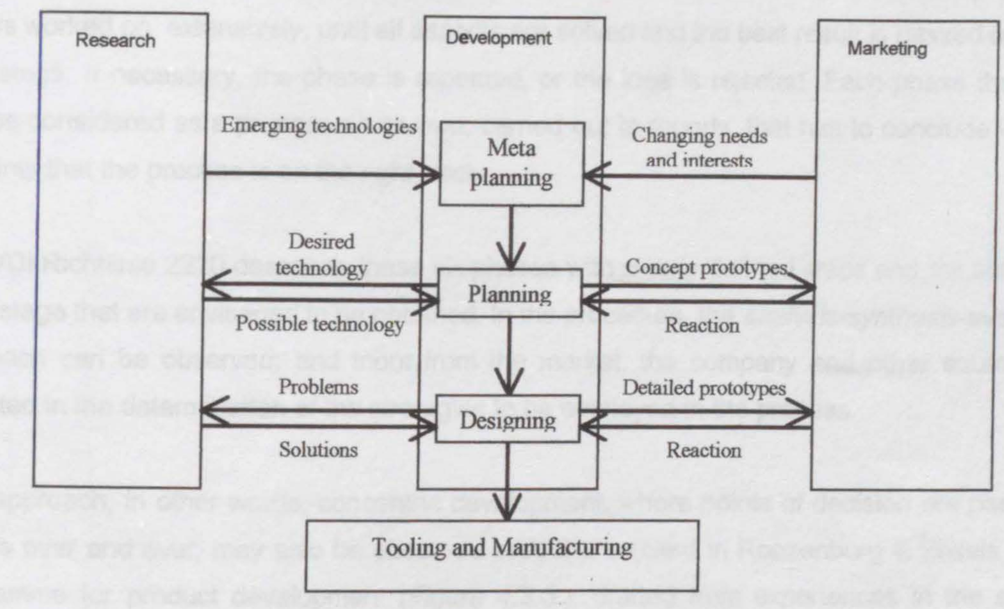


Figure 4.3.1. The business context: appropriate interactions at appropriate times (Owen, 2001: 33).

Owen (2001) represents the parallel functioning of research, development and marketing in *Figure 4.3.1.*. Research is vital in the process, as it investigates technological possibilities, and user interest. The relationship between development and research before the project initiation, is one of technology assessment, at the metaplanning level; the relationship with marketing is of needs and interests emerging in the society. At the planning stage of development, the research team suggests the available technologies to the planning team, and the marketing team offers feedback on the proposed concept prototypes back to the planning team. At the designing level, research handles the technological problems and solutions; marketing deals with the field-testing of the detailed demonstrations and prototypes (Owen, 2001).

According to Pahl and Beitz (1996), decisions for product planning have to consider external and internal stimuli from the market which involve: the technical and economic position of the company's products in the market when changes occur; in such as fashion or new functions; complaints and suggestions from users; technical and economic superiority of competing products; economic and political changes; new technologies and research results; and environment and recycling issues. Stimuli from within the company may be: new ideas and results of company research to be applied in development and production; new functions to satisfy and extend the market; introduction of new production methods in the company; rationalisation of product range and production; and increasing the degree of product diversification, that means the range of products with life cycles that are planned to overlap. These stimuli affect decisions on the five main working steps of analysing the situation of the company and its product, formulating search strategies, finding product ideas, selecting product ideas, and defining products by elaborating the product ideas (*Figure 4.3.2.*).

To minimise the risk of failure of a product in the market, the principle of *concentric development* may be employed where the project is divided into a number of phases and in each phase, an idea is worked on extensively, until all aspects are solved and the best result is passed on to the next stage. If necessary, the phase is repeated, or the idea is rejected. Each phase therefore, can be considered as a process on its own, carried out in rounds, that has to conclude with the certainty that the process is on the right track.

The VDI Richtlinie 2220 describes these six phases with clearly defined steps and the outputs of each stage that are envisaged to be obtained. In the procedure, the *analysis-synthesis-evaluation* approach can be observed; and input from the market, the company and other sources are reflected in the determination of the strategies to be employed in the process.

This approach, in other words, concentric development, where points of decision are passed in rounds over and over, may also be observed in Archer's (cited in Roozenburg & Eekels, 1985) programme for product development (*Figure 4.3.3.*), drafted from experiences in the area of engineering product development. The programme again is parallel with the *analysis-synthesis-evaluation* approach, as is expressed in the stages *strategic planning- research-design-development-manufacturing marketing set-up-and production.* Although the steps offered in the stages may not be equally important in every project, nor all the activities relevant (Roozenburg & Eekels, 1985), in this procedure, business related issues such as strategy determining, marketing, tooling and production planning play a role of equal importance as the design activity itself, and so is an example of a programme for product development handling the problem in its entirety. Archer represents this procedure in a linear sequence of actions and decision points, all the same reflecting the cyclic development of the project in its totality, suggesting many rounds for determining specifications (*specification 1, 2,and 3*), designing (*sketch designs 1, design 2 and 3*), and evaluation (*trials 1, 2 and 3*). Through the insights gained from these rounds, he suggests that recommendations for future projects can be made, as an end product of these cycles.

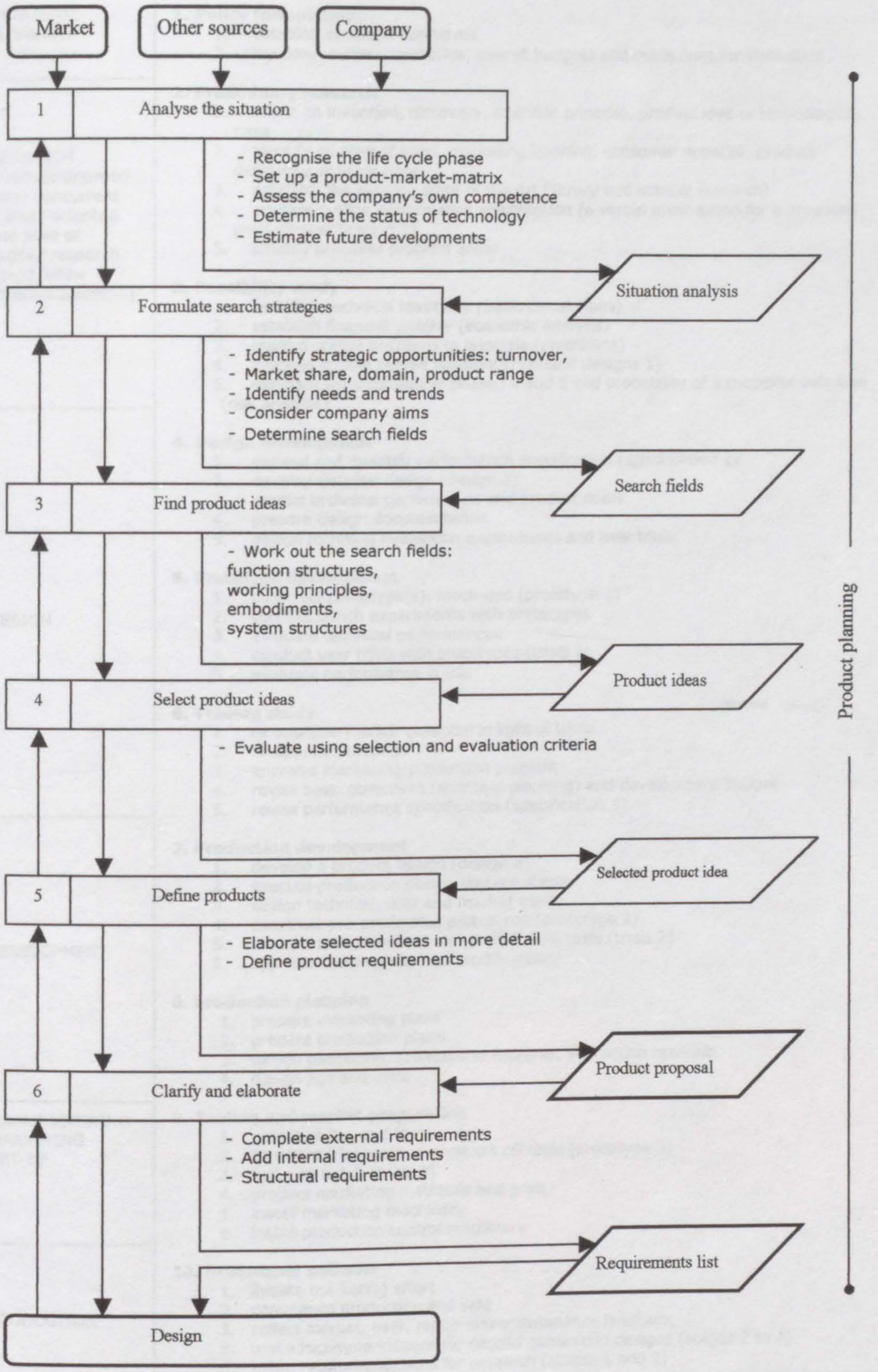


Figure 4.3.2. Procedure of product planning after Kramer, 1986 and VDI-Richtlinie 2220, 1980 (Figure from Pahl & Beitz, 1996: 121).

STRATEGIC PLANNING	**1. Policy formulation** 1. establish strategic objectives 2. lay down outline timetables, overall budgets and guide lines for innovation
RESEARCH [Product-oriented only: concurrent market-oriented and pure or applied research would follow different patterns]	**2. Preliminary research** 1. select an invention, discovery, scientific principle, product idea or technological base 2. identify an area of need, marketing opening, consumer appetite, product deficiency or value base 3. establish the existing state of the art (library and market research) 4. prepare outline performance specification (a verbal prescription for a proposed product-specification 1) 5. identify probable problem areas **3. Feasibility study** 1. establish technical feasibility (basic calculations) 2. establish financial viability (economic analysis) 3. resolve critical problems in principle (inventions) 4. propose outline overall solution(s) (sketch designs 1) 5. estimate work content of phases 4 and 5 and probability of a succesful outcome (risk analysis)
DESIGN	**4. Design development** 1. expand and quantify performance specification (specification 2) 2. develop detailed design (design 2) 3. predict technical performance and product costs 4. prepare design documentation 5. design technical evaluation experiments and user trials **5. Prototype development** 1. construct prototype(s), mock-ups (prototype 1) 2. conduct bench experiments with prototypes 3. evaluate technical performancee 4. conduct user trials with prototypes (trials 1) 5. evaluate performance in use **6. Trading study** 1. re-appraise market potential in light of trials 2. re-appraise costings 3. appraise marketing/production problem 4. revise basic objectives (strategic planning) and development budget 5. revise performance specification (specification 3)
DEVELOPMENT	**7. Production development** 1. develop a product design (design 3) 2. execute production design documentation 3. design technical, user and market trials 4. construct pre-production prototypes (prototype 2) 5. conduct technical, user and market field tests (trials 2) 6. appraise trials results and modify design **8. Production planning** 1. prepare marketing plans 2. prepare production plans 3. design packaging, promotional material, instruction manuals 4. design jigs and tools
MANUFACTURING MARKETING SET-UP	**9. Tooling and market preparation** 1. construct jigs and tools 2. construct trial batch of products off tools (prototype 3) 3. test trial batch (trials 3) 4. product marketing materials and print 5. install marketing machinery 6. install production control machinery
PRODUCTION	**10. Production and sale** 1. initiate marketing effort 2. commence production and sale 3. collect market, user, repair and maintenance feedback 4. make recommendations for second generation designs (stages 2 to 4) 5. make recommendations for research (stages 1 and 2)

Figure 4.3.3. A characteristic programme for product development by Archer (cited in Roozenburg & Eekels, 1985: 113-114).

Pugh (1996) with a similar concern, offers the concept of *Total Design*, which he defines as the systematic activity that should be followed from identification of the market or user need, through to selling, in order to produce competitive products for world markets. As without a structured approach to design, the user and need situation may never be satisfied, Pugh suggests a design activity model to establish a common ground between various types of design (*Figure 4.3.4.*). Total design is seen as a broadly based business activity in which specialists collaborate in the entire process. An important point here is the belief that design is an interdisciplinary process, and success in the marketplace requires total design rigour and engineering rigour of the highest order, working together in balance.

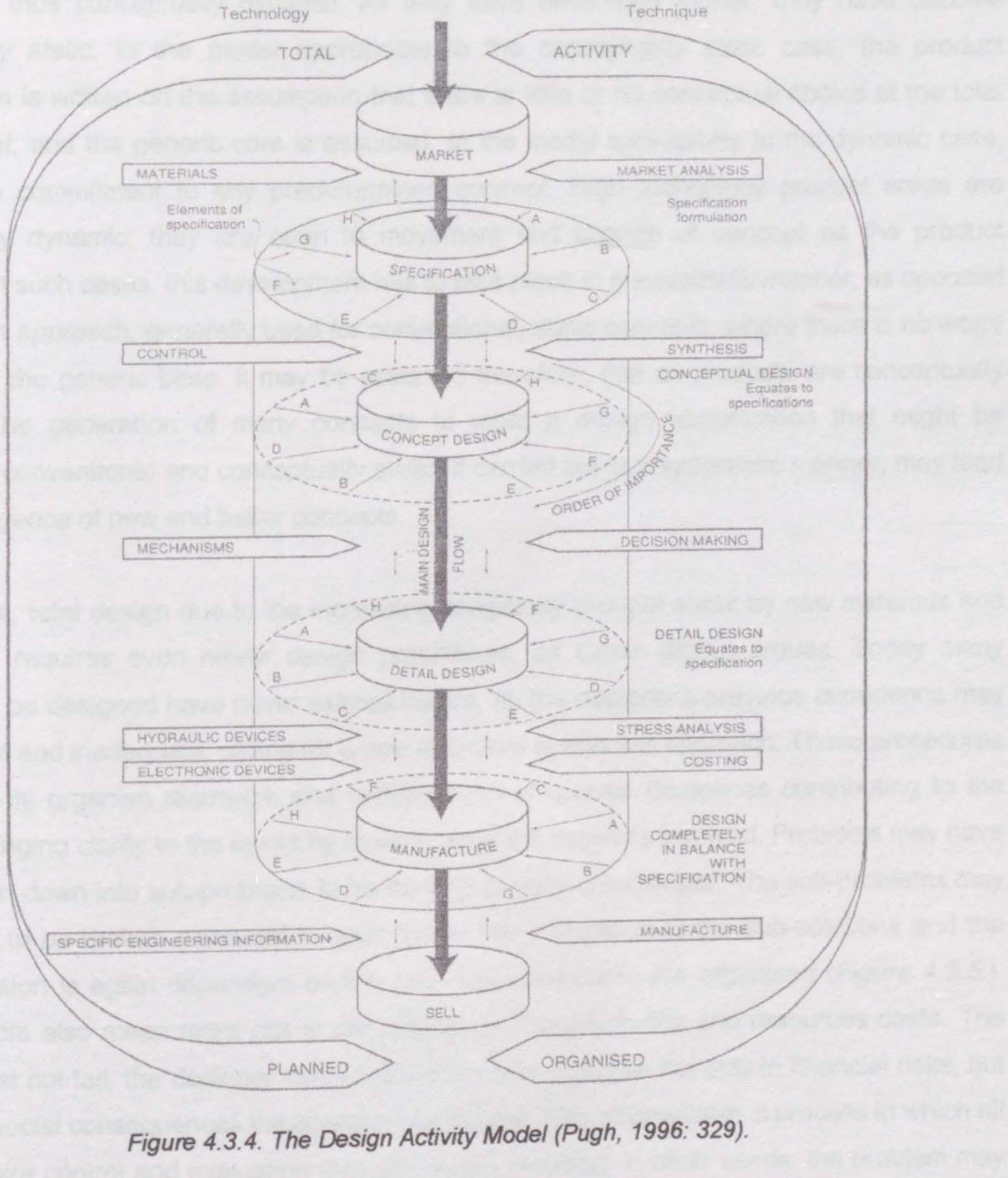


Figure 4.3.4. The Design Activity Model (Pugh, 1996: 329).

In the centre of the design activity model Pugh (1996) proposes, is the *core*, the first major area of the design activity, that consists of the core phases of *market investigation*, *product design specification*, *concept design*, *detail design*, *manufacture and sales*, which Pugh argues are universal and common to all kinds of design. Different kinds of design will require different information, techniques, and management. The inputs to the design core will have to be reconsidered depending on each new case. Within this core, the engineering and nonengineering inputs have to be balanced. The designer has to have a knowledge and awareness of the techniques available to help its working, to set it in motion and to improve its function and performance.

Whether a *generic base* has been found or not in a concept, brings a distinction on the product design activity model. For Pugh (1996), a *generic base* is the concept that contains all the attributes of the competing concepts without attracting their deficiencies, an ideal situation that in reality can never be true. All products can be assumed as once having been novel and innovatory, thus *conceptually dynamic*. As they were developed further, they have become *conceptually static*. In the model appropriate to the conceptually static case, the product specification is written on the assumption that there is little or no conceptual choice at the total system level, and the generic core is assumed. In the model appropriate to the dynamic case, there is no commitment to any predetermined concept. High technology product areas are conceptually dynamic; they are open to movement and change of concept as the product develops. In such cases, this development has to take place in a *systematic manner*, as opposed to a *random approach*, generally used for conventional, static concepts, where there is no worry of attaining the generic base. It may be assumed therefore, that all products are conceptually dynamic. The generation of many concepts to meet a design specification that might be considered conventional and conceptually static, if carried out in a systematic manner, may lead to the emergence of new and better concepts.

To conclude, total design due to the increasing complexity brought about by new materials and technology, requires even newer design procedures, as Cross (2000) argues. Today many products to be designed have never existed before, so the designer's previous experience may be irrelevant and inadequate, calling for a new and more systematic approach. These procedures must primarily organise teamwork and collaboration of diverse disciplines contributing to the process, bringing clarity to the layout by co-ordinating the activities involved. Problems may have to be broken down into sub-problems to be handed to each collaborator. The sub-problems may again have to be broken down within each team. The integration of the sub-solutions and the overall solution is again dependent on the way new procedures are organised (*Figure 4.3.5.*). New products also mean more risk in the setting up, manufacturing and resources costs. The product must not fail, the designer cannot afford to make mistakes not only in financial risks, but also in the social consequences the product may involve. This necessitates a process in which all stages require control and evaluation through careful planning; in other words, the problem may have to be broken into sub-problems, but the design process must be undertaken in its totality, by checking and rechecking results at phases and always relating and integrating them into the totality.

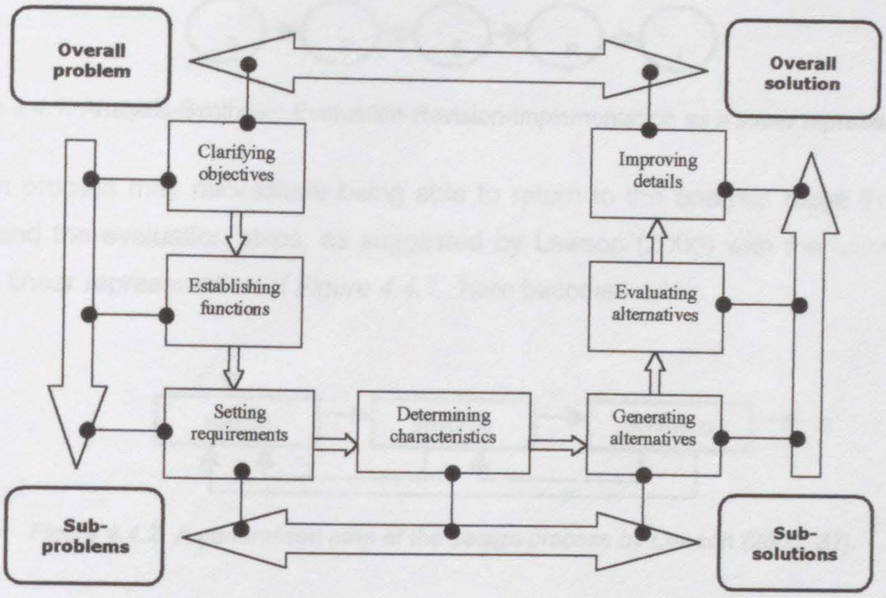


Figure 4.3.5. Seven stages of the design process positioned within the symmetrical problem/solution model (Cross, 2000: 58).

4.4. THE DESIGN PROCESS IN ITS STRUCTURAL CONTEXT IN CONJUNCTION TO DESIGN METHODS

As emphasised in the previous sections, models employed in different fields of design, and for differing situations, require different structuring of the design process. A major concern in selecting methodology is deciding on how the design process is going to be laid out. Jones (1980) describes design processes as either *linear* or *circular*. Design processes of circular nature in general, are developed for novel problems that require novel solutions. As circularity implies that sub-problems may remain untackled until later stages in the process and may require a revision of critical decisions which may lead to the cancellation of the project or at least to loss of time, a linear layout may be more desirable. Linearity implies that all critical concerns are spotted at the beginning of the process and are taken into account while proceeding along familiar problems that do not require radical solutions. All the same, a linear layout must allow returning to previous stages, in other words iteration, as many times as necessary.

The way the model is represented, also gains importance. Pugh (1996) votes for a model that is self-expressive and comprehensive. If verbal, the models may be too descriptive and difficult to understand; if graphical, confusing and non-familiar. Models tend to use the same words, but under different meanings and arrangements. To the design process, which we have seen to include the three essential steps of *analysis*, *synthesis* and *evaluation* (*a-s-e*), Tovey (1997) adds two more steps: *revision* and *implementation* (*Figure 4.4.1.*). A single sequence of a-s-e will offer an end product, but not an adequate design solution. *Revision* may be needed to evaluate the concept, design and production decisions, and *implementation* for the necessary modifications, until the final product is obtained.

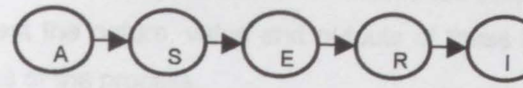


Figure 4.4.1. Analysis-Synthesis-Evaluation-Revision-Implementation *as a linear representation.*

The design process may necessitate being able to return to the analysis stage from both the synthesis and the evaluation steps, as suggested by Lawson (2000) with the following *Figure 4.4.2.*. The linear representation of *Figure 4.4.1.*, here becomes cyclic.

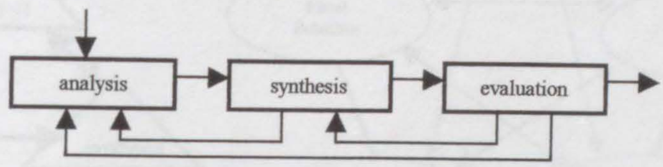


Figure 4.4.2. A generalised map of the design process by Lawson (2000: 37).

Analysis-synthesis-evaluation is not only a single sequence of stages along the process; this cycle may also take place among the steps of certain stages of the process. Markus and Maver's (1969b; 1970; cited in Lawson, 2000) map in *Figure 4.4.2* is a representation of an architectural process, where the process requires both a design sequence and a decision sequence. Each stage is thus treated as a process in itself where the activities of *analysis*, *synthesis* and *appraisal* take place to produce a decision to pass onto the next stage.

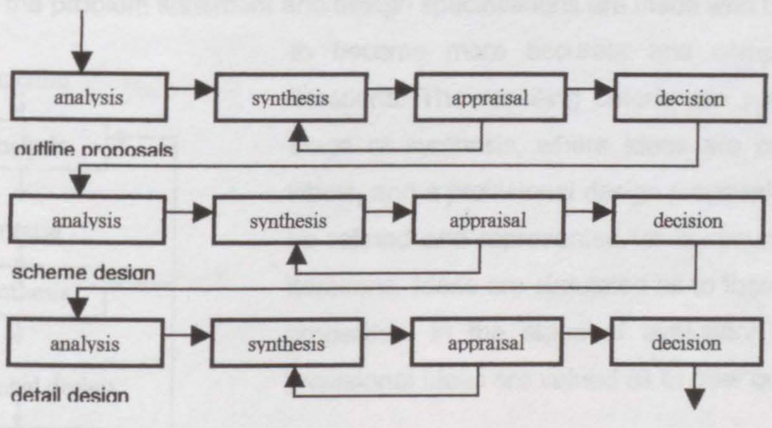


Figure 4.4.3. The Markus/Maver map of the design process (Figure from Lawson, 2000: 35).

Figure 4.4.4. represents breaking loose from linearity and displays a cyclic nature, showing the interrelationships of the three main stages. Still, it remains too generalised and abstract, thus insufficient at expressing the inputs and outputs of each stage, and of the process as a whole. Lindbeck (1995) represents the stages of the design process as an interrelationship of activities and results (*Figure 4.4.5*).

The design process is a sequence of the stages where the problem is identified, relevant data are collected, a hypothesis is made in the form of a design, tested and a final solution obtained according to the revisions that the testing necessitates. Although this sequence seems to be linear, the stages are interdependent. Lindbeck's process representation may be inadequate in expressing the iterative nature of the process, as it remains too simplified, and the relationships too generalised to suggest the nature, value and outputs of these interdependencies, in other words, the inner dynamics of the process.

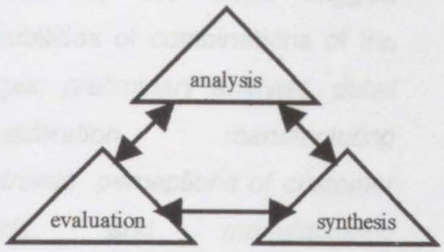


Figure 4.4.4. A more honest graphical representation of the design process according to Lawson (2000: 38).

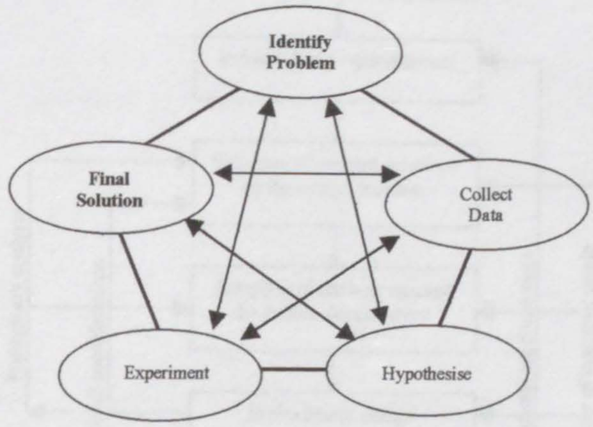


Figure 4.4.5. The inner dynamics of the design process according to Lindbeck (1995: 98).

The basic design cycle of Roozenburg and Eekels (1995) may be a better example to illustrate the iterative nature of the process (*Figure 4.4.6.*). The *analysis* stage begins once the function is determined and the problem statement and design specifications are made with broad definitions to become more accurate and complete in further iterations. The resulting criteria are passed on to the stage of synthesis, where ideas are combined into a whole, and a provisional design proposal is generated to be refined and represented for communication through iterations. Ideas are simulated as to their behaviour and properties. In the stage of evaluation, the simulated provisional ideas are valued as to their qualities.

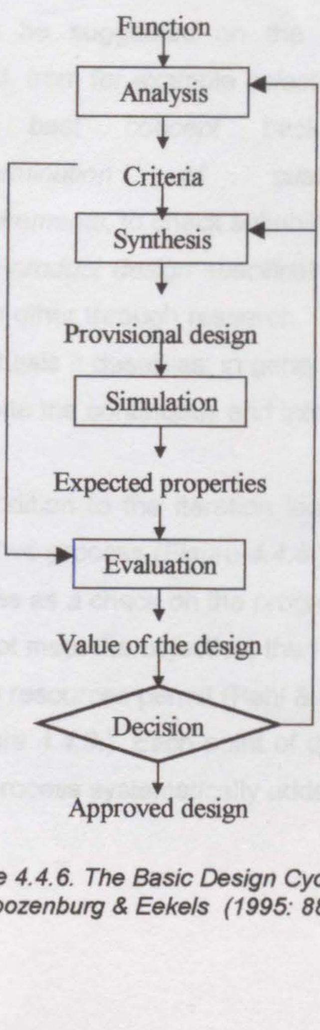


Figure 4.4.6. The Basic Design Cycle by Roozenburg & Eekels (1995: 88).

Evaluating and selecting may require iterative decision making, until one idea is chosen as the final design, or the single idea that came up to the evaluation stage is elaborated. If necessary, as may frequently be the case, the team returns to the analysis or synthesis stages to reconsider previously taken acts and decisions. Pahl and Beitz (1996) suggest that design activities have to be structured in a purposeful way, by sequencing the main phases and individual working steps to give the process a flow of work, that can be planned and controlled. As seen in *Figure 4.4.6.*, the basic design cycle provides a clear sequencing, interconnected with a loop, making the process a cycle.

Figure 4.4.7. by Wright (1998) is another representation of feedback and feed-forward loops that the process permits. The connections defined by the loops suggest possibilities of combinations of the stages: *preliminary analysis*, *detail consideration*, *manufacturing contraints*, *perceptions of customer needs*, and *manufacturing considerations*; further loops may be suggested depending on the design situation and how the process is carried out. The first loop Wright suggests is at the *embodiment* stage, for *preliminary analysis*, leading back to reconsider the generation of concept solutions and concept selection. Earlier loops may be suggested on the other hand, from for example *selection of the best concept* back to *determination of customer requirements*, to check suitability; or from *product design specification* back to *customer requirements*, interacting with and affecting each other through research. Only a few models seem to give product design specifications the emphasis it deserves; in general it seems not to be considered part of the actual design activity, despite the continuous and interactive technical and conceptual support it provides.

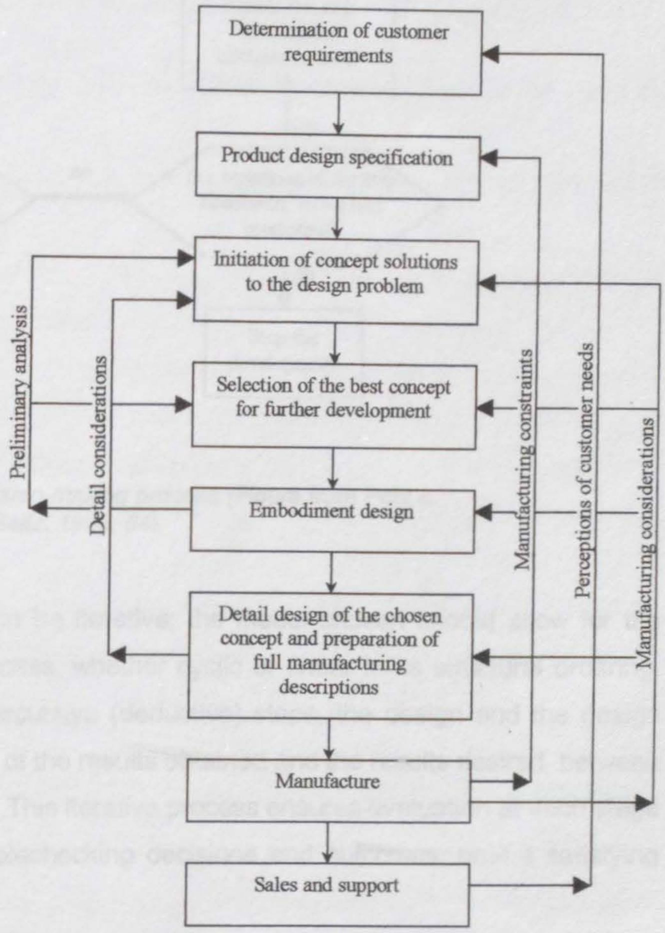


Figure 4.4.7. The design process with 'feedback' loops (Wright, 1998).

In addition to the iteration loops between stages, a decision made at each stage is itself an iterative process (*Figure 4.4.8.*). Each stage of the process will require evaluation, as evaluation serves as a check on the progress towards the overall objective. If the results of a previous stage do not meet the objective, then the stage may have to be repeated on a higher information level, if the resources permit (Pahl & Beitz, 1996). The design process thus becomes an iterative spiral (*Figure 4.4.9.*). Each point of decision-making develops bit by bit as described above, and thus the process systematically adds onto the design.

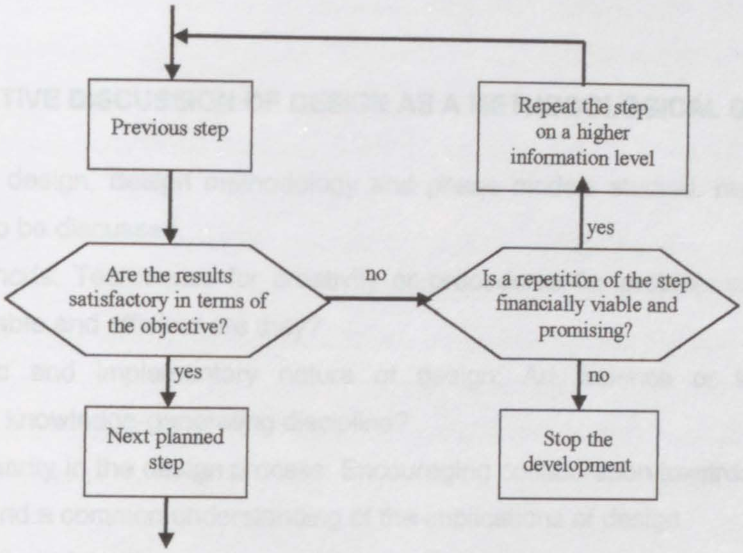


Figure 4.4.8. General decision-making process (Figure from Pahl & Beitz. 1996: 64).

To conclude, the design layout needs to be iterative; the model chosen should allow for the iteration at each step of the design process, whether cyclic or linear in its structural ordering. Through the intuitive (reductive) and discursive (deductive) steps, the design and the design specification develop, with a comparison of the results obtained and the results desired, between each step (Roozenburg & Eekels, 1995). This iterative process ensures evaluation at each stage of the process, thus checking and doublechecking decisions and outcomes, until a satisfying output is obtained.

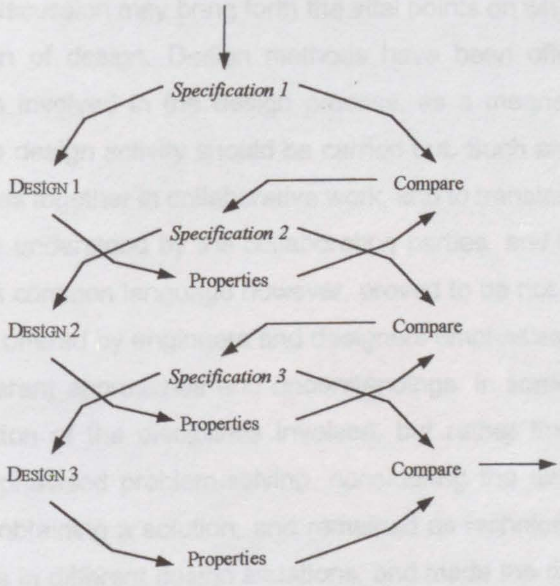


Figure 4.4.9. The iterative structure of the design process (Roozenburg & Eekels, 1995: 93).

5. AN EVALUATIVE DISCUSSION OF DESIGN AS A METHODOLOGICAL DISCIPLINE

The review on design, design methodology and phase models studied, reveals the need for certain issues to be discussed.

1. Design methods: Techniques for creativity or procedures for problem-solving? How much valid, applicable and efficient are they?
2. The intrinsic and implementary nature of design: Art, science or technology; or an independent knowledge-generating discipline?
3. Multidisciplinarity in the design process: Encouraging collaboration towards the generation of knowledge and a common understanding of the implications of design.
4. The contribution of design practice and design research to the generation of knowledge.
5. The role of the designer: A tool for the application of design methods; or a factor of creativity and human touch in the technical procedures?
6. The role of the user: The user as a group of persons who are going to use the product, besides a group of persons who confront innovation and who are the purchaser of the products.

5.1. THE APPLICABILITY AND EFFICIENCY OF DESIGN METHODS: FROM DESIGN METHODS TO PHASE MODELS

In the previous three chapters, process and methodology in design were extensively discussed. A brief summary of this discussion may bring forth the vital points on which to base arguments in the evaluative discussion of design. Design methods have been offered as procedures for engineers and designers involved in the design process, as a means of bringing a common understanding of how the design activity should be carried out. Such an attempt was necessary to bring different disciplines together in collaborative work, and to translate the design activity into a language that could be understood by the collaborating parties, and by those who evaluated the process afterwards. A common language however, proved to be not entirely possible, as the methods and procedures offered by engineers and designers emphasise different aspects of the design process, with different approaches and understandings. In some cases, these methods suggested not collaboration of the disciplines involved, but rather their separation. Methods offered by engineers emphasised problem-solving, considering the design process as one of problem-solving towards obtaining a solution, and remained as technical procedures that could be employed like formulas in different design situations, and made the designer formulae-bound (Mayall, 1966). Methods offered by designers mainly emphasised creative thinking and remained as techniques to encourage the use of diverse thinking strategies. To both, it was argued that any unstructured but condense and concentrated thinking phase would produce similar outcomes; and also that, the application of any method could not be desirable, as design is such an activity that, repeating the same steps would be wrong in different design situations.

The common language that failed to be built, was searched in the use of computers which today can process information related to all fields. Apart from information processing software, modelling software used in computers are tools that help speed up the design activity. Yet, creative and intuitive skills of the designer is not translatable into computers.

In the forthcoming sections, these issues will be discussed with the view of arriving towards a proposal for a design task that will be undertaken as a case study. A final point will thus be to suggest that, generally applicable methods do not exist particularly in the field of design. Methods were found difficult to understand, difficult to apply to different design situations, and segmenting the phases of the design process. Even as these methods are applied, subjective thinking, insight and experience play a role and absolute objectivity cannot be provided, as there is always a decision-making human involved. To resolve this problem between bringing together the controlled and systematic problem-solving attempt of the engineer and the creative thinking of the designer, phase models have been suggested. The relevant methods and techniques can be chosen and integrated into these models to produce an efficient outcome, in answer to specific situations. Controlled creativity alongside careful and multidisciplinary planning of the design process is how the design activity can be best carried out, and is most suitable to the nature of the design activity as understood today.

5.2. DISCUSSION OF DESIGN AS TO ITS INTRINSIC AND IMPLEMENTARY NATURE

Of the issues stated above, an important one that needs to be discussed in the scope of the thesis is: Is design a field of art, science or technology? Is design a discipline in its own rights, which produces knowledge, related to design? Since early discussions on this subject in the 1960s, it is particularly stressed that design is neither art, nor science, nor an activity that might be confused with mathematics. As Jones (1980) points out, design is a hybrid activity which blends all three, and cannot be identified with only one. The attitudes, tools and criteria in all three fields bring forth this distinction. An artist works with his imagination in representing symbolically his will through the manipulation of a medium that exists at the same time as his actions. He acts in the present, using his artistic skills to the full capacity, in an intuitive manner, without the worry of bringing evidence to support his imagination. The attitude of the scientist is of trained scepticism and doubt, his tools are experiments that are set up to disprove hypotheses by searching for truth in a statement of the opposite. A scientist describes precisely, and explains phenomena that exist in the present. Mathematicians on the other hand, operate on abstract relationships, independent of historical time. The world of mathematics is not physical. Any problem that is said to exist is represented symbolically, and brings no scientific doubts and explanations.

Designers treat as real, that which exists in an imagined future, and have to specify the ways in which they can be made to exist (Jones, 1980). Designers need scientific doubt and the ability to set up and observe the results of a controlled experiment to know about the present, before they can predict the future. When they are dealing with future, they can no longer make use of scientific doubt, but have to employ other ingredients, closer to religious faith. From an artistic approach, designers have to search through great numbers of alternatives in determining the pattern upon which they will base their decisions. They will have to quickly represent their thoughts that reflect the forms of the problems, using artistic skills. Designers can use mathematical symbols and methods only when the problem in hand is stable and its assumptions are not going to be changed while resolving conflicts between aims and details.

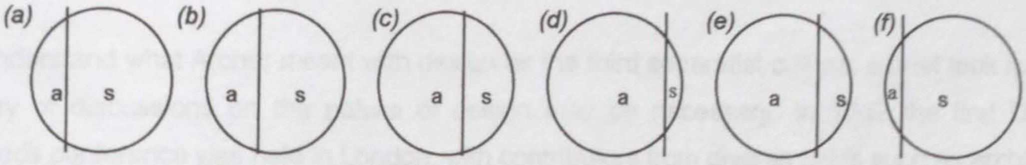


Figure 5.1.1. The balance between art and science: (a) Fossil-fuelled power station, (b) Family house, (c) Textile fabric, (d) Sculpture, (e) Painting, (f) Textile loom (Figure from Pugh, 1996: 93).

As opposed to Archer's view of design as a *third culture*, a separate discipline with its own language and syntax, also supported by Cross (2001), Pugh (1996) argues that design is not a body of knowledge, but is the activity that integrates the bodies of knowledge present in the arts and sciences. That design is the third culture is only a separatist view which has been developed to render design special, but which results with further confusions on what design really is. Accordingly, engineering, Pugh suggests, is the application of the sciences in the *science of humanity*, which through the activity of design, manifests itself in artefacts. The existence of new artefacts adds to the relevant bodies of knowledge. The scale of the artefacts detaches the original designer from the making activity, and the further the designer is detached, the more the design activity becomes a collaborative integration of art and science through technology. Engineering is considered the application of the sciences, but form, shape, colour and aesthetics are considerations of art; the whole of such an activity is explained as design. Considered in this way, design must use the language, grammar and syntax of both cultures to become understood, though design cannot be integrated into the syllabus of the other two cultures, but acts as the integrator, bridging the gap between the two. It is then that the balance and distribution of the arts and sciences contents, distinguishes the scale of the artefacts (*Figure 5.1.1.*).

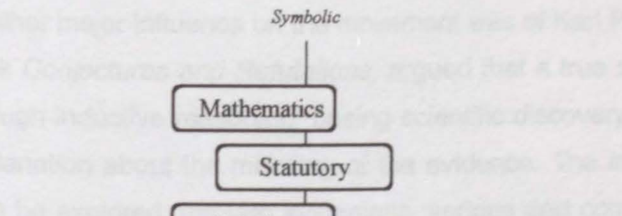


Figure 5.1.2. A Map of Disciplines (Owen, 1998: 10).

For example, in the Map of Disciplines (*Figure 5.1.2.*), Owen (1998) represents the positionings among traditional fields of study and practice, defined by two axes. The *analytic/synthetic* axis separates the map into two halves where fields take position according to their orientation towards finding or discovering (analytic) or towards making and inventing (synthetic). The *symbolic/real axis* separates the map vertically, where disciplines position themselves according to their nature. Although subjective and relative, the position of product design represents an almost entirely synthetic procedure, with content displaying a balance of the symbolic and real, with an orientation towards dealing with real world phenomena.

5.2.1. A BRIEF HISTORY OF DISCUSSIONS ON THE NATURE OF DESIGN

To understand what Archer meant with design as the third separatist culture, a brief look into the history of discussions on the nature of design may be necessary. In 1962 the first Design Methods conference was held in London, with contributors from diverse fields such as architects, engineers, computer scientists, ergonomists, industrial designers, planners, cognitive psychologists and systems analysts. In 1966, the Design Research Society was formed, on the belief that thinkers and practitioners from these fields had common ways of thinking and working, and that the cognitive processes of matching a perceived need with a proposed configuration were the same or similar in all these fields of application (Archer, 1999). This belief had arisen from the studies carried out on the cross-disciplinary teamwork undertaken during the Second World War, on the optimisation of food production and distribution, the development of weapons systems, the search for means of defence against the enemy weapon systems, the development of new materials, the formulation of war-time logistics, the organisation of shipping across the oceans, the development of computer systems, and even search for strategies for military operations, as was briefly mentioned in *Section 2.2.*. Such work resulted in the evolution of a new discipline, *operational research*, characterised by the cross-disciplinary collaboration of engineers, scientists, and others from diverse backgrounds. This discipline brought its own approach, the *systems approach*, to the analysis of problems. The Design Methods Movement that began in the 1960s, was a result of this post-operational research era, and systems analysis was the dominant source of the early thinking of the movement.

Another major influence on the movement was of Karl Popper (cited in Archer, 1999), who, in his book *Conjectures and Refutations*, argued that a true scientist must arrive at a scientific theory through inductive reasoning, basing scientific discovery on the positing of an insightful tentative explanation about the meaning of the evidence. The implications of such an explanation could then be explored, through systematic, serious and comprehensive attempts to find flaws in the posited theory. Popper called this process *conjecture, exploration* and *refutation*. This argument had a great impact among design thinkers, who argued that this was what designers did, therefore, the design activity was scientifically respectable. Research could then be conducted through the design activity, as it could by orthodox scientific inquiry. Hence, the new discipline of *design research* developed.

The Design Methods Movement also identified certain areas of discussion that seemed to be a result of technological development and mass-production. As mentioned in *Section 2.3.*, Jones (1980) argued that traditional design methods could no longer cope with the increasing complexity of problems. The design process had to be extended from the products level to the systems level. Working on the systems level required improved collaboration within the design process. Alexander (1970) argued that from the unselfconscious craft-based approach of the traditional design activity, the designer had to move on to the selfconscious professionalisation of design. Designers had to become multi-professional, to be able to make intuitive decisions based upon prior knowledge and experience. On the basis of all these arguments lay design methodology as a field of study. Principles, procedures and practices of design were studied, new methods were devised. How the designer thinks and acts were also a subject of study, and the above listed arguments were all incorporated into an understanding of the design process, through the use of methods and models. During this period, the methods and techniques employed in other fields such as engineering, management and computer sciences were also studied and ways to incorporate them into the design process were searched for.

5.2.2. SCIENTISING DESIGN

Cross (2001) argues that the attempts at scientising design can be seen in the 1920s with the de Stijl movement, which was followed by the modern movement, when designers were concerned with *scientifically* developed designs, as opposed to influences from nature and against the instinctual intuition that the designer may bring. Particularly in the modern movement, the functions of a product, reflected logical reasoning as to how it related to the system into which it was built, to the material of which it was constructed, and to the persons by which it was going to be used. The Design Methods Movement showed stronger attempts at this scientising of design, as now, not the end product, but the entire design process was inspected under the light of scientific inquiry, towards the reflection of scientific traces in the process. *Objectivity* and *rationality* were the keywords for this era, and not the *designer* any longer, but the *design team* working in a rational sequential manner, aided with scientific and computational techniques, became important.

In the 1970s, there was a change of mind, and the movement was hampered with criticisms on its values and approaches, from even its pioneers. Alexander (cited in Cross, 2001) stated that he no longer believed in the use of design methods. Jones expressed reaction against methods refuting the attempts at expressing the design behaviour within a logical framework:

> 'I dislike the machine language, the behaviourism, the continual attempt to fix the whole of life into a logical framework. (...) I realise now that rational and scientific knowledge is essential for discovering the bodily limits and abilities we all share but that mental process, the mind, is destroyed if it is encased in a fixed frame of reference (Jones, 1984b: 333).'

Obviously there was lack of success in the application of *scientific* methods to design practice in general. Perhaps the critical distinction was made too late: methods may be necessary in the practice of science, but not in the practice of design, where results do not, or in some cases, must not be repeated. The main argument was shaped as follows: rather than design learning from science, perhaps science had something to learn from design. Design methodology continued to grow in engineering and some branches of industrial design. Finally, to bring a distinction or to understand the relation between science and design, Cross' (2001) definitions of *scientific design*, *design science* and the *science of design* will here be studied.

Scientific design: is modern, industrialised design, which applies scientific knowledge in practice, thus making science visible, through a mix of intuitive and nonintuitive design methods.

Design science: is concerned with deriving appropriate information from the applied knowledge of natural sciences for the designer's use (Hubka & Eder, 1987; cited in Cross, 2001). The present state of design knowledge, according to Hubka and Eder (1996), indicates that there is much knowledge accummulated, but little synthesis pursued to unify this knowledge. The quality of knowledge varies from experience to precise statements, and linguistic barriers seem to exist between fields of design and other disciplines. Design science must be thus understood as a system of logically related knowledge that contains and organises the complete knowledge about and for designing. Science is used in the sense that, this organisation needs systematic descriptions, methodology, instructions for the practical activity, and techniques for partial processes and operations. The goal of such an organisation is to investigate the design process as generally as possible, organising, storing and referencing all knowledge for and about designing. *Figure 5.2.1.* represents the hierarchical planes of knowledge in which design science is situated.

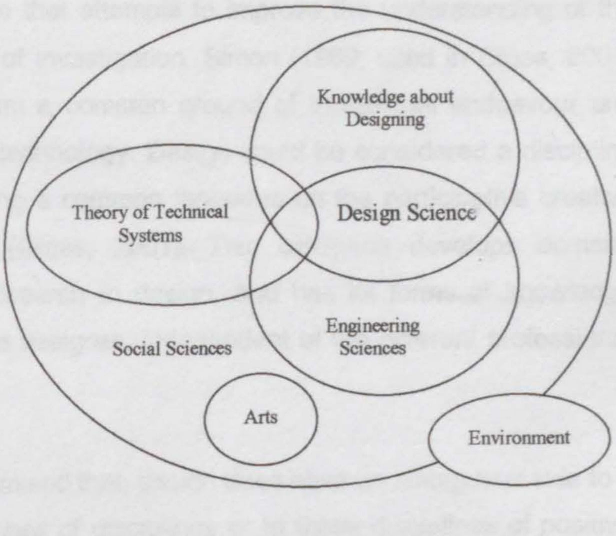


Figure 5.2.1: Branch (domain) knowledge in hierarchical planes (Figure adapted from Hubka & Eder, 1996 : 47).

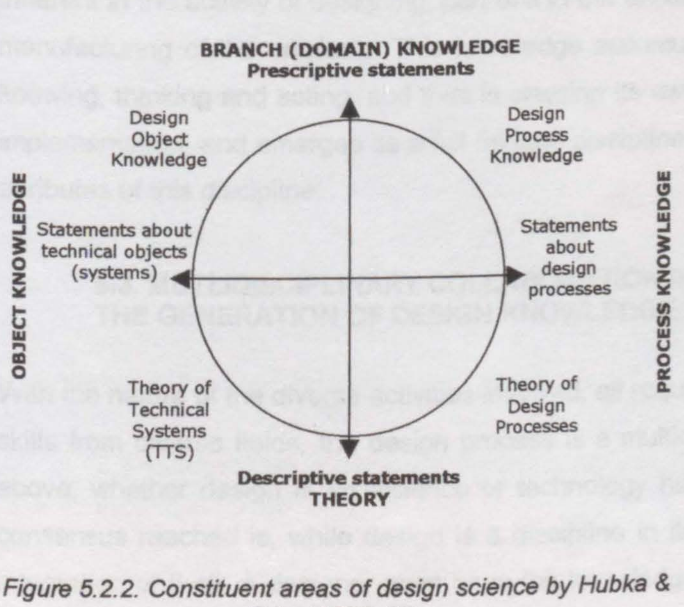


Figure 5.2.2. Constituent areas of design science by Hubka & Eder (1996: 97).

Thus, design science is constituted of diverse information, phenomena and knowledge related to design, and other disciplines that design interacts with, both in theoretical and in practical means, as represented in *Figure 5.2.2.*. The *Theory of Technical Systems* is concerned with descriptive statements describing, explaining and justifying the object of design, or the technical system to be designed. The *Theory of Design Processes* is concerned with the complete design process knowledge as a holistic unit of transformation, and comprises the task of design processes, transformation technologies in design processes, structures, procedures, tactical instruments, influencing factors for the results and efficiency, evaluation, characterisation and effects on the design process. *Branch Knowledge* includes prescriptive statements closely related to engineering practice, which contain the practical knowledge that answer the immediate questions of designers on what the problem is, how it is formulated, and with what process and procedures it may be solved.

Science of design: is the field of science that attempts to improve the understanding of the design activity through scientific methods of investigation. Simon (1969; cited in Cross, 2001) suggests that science of design could form a common ground of intellectual endeavour and communication across arts, sciences and technology. Design could be considered a discipline with its own terms and own culture, offering a common language on the participative creative activities that different fields carry out (Cross, 2001). This discipline develops domain-independent approaches to theory and research in design, and has its forms of knowledge specific to the awareness and ability of the designer, independent of the different professional domains of design practice.

From all the above arguments it may be surmised that, design does have an ambiguous side to it as to its links to the more traditional branches of disciplines or to those disciplines of positive sciences with which one knows where one stands. However, design, though multidisciplinary, is a discipline on its own. 'Design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of it', as Cross (2001: 54) explains. Part of this knowledge is inherent in the activity of designing, part of it in the artefacts of the artificial world and part in the manufacturing of the artefacts. This knowledge accumulates as a result of designerly ways of knowing, thinking and acting, and thus is creating its own professional approaches and ways of implementation, and emerges as a full fledged discipline. The next section will discuss the main attributes of this discipline.

5.3. MUTLIDISCIPLINARY COLLABORATION IN THE DESIGN PROCESS TOWARDS THE GENERATION OF DESIGN KNOWLEDGE

With the nature of the diverse activities involved, all requiring individually related knowledge and skills from diverse fields, the design process is a multidisciplinary collaboration. As discussed above, whether design is art, science or technology has always been a topic of debate. The consensus reached is, while design is a discipline in its own rights, the design process is an integration of it all. A designer must have the knowledge and skills related to design, but also, must have the skills of integrating the various knowledge and skills that contribute to the design process, by deciding on when, where and how much of them to use.

The interdisciplinary potential that can be observed through the representation of the design process means that, design requires active collaboration from many disciplines such as management, economics, engineering, and behavioural sciences. Designers search for a solution within *solution spaces*, which are alternative new states of knowledge, involving knowledge from different domains (Snoek and Hekkert, 1998). The fact that, apart from the designer's own knowledge, it will be necessary to consult persons from other disciplines related to many issues involved in the problem, will help designers to depart from their constrained solution spaces to extend to those of other disciplines (Hekkert, 1997). The designer can then structure the design problem (theoretically) and search for solutions (practically). The structure of the process can display the amount of this collaboration and the timing for it, depending on each individual design task. Design research as a scientific activity can therefore also study the nature of such collaboration, and its implications on the process, the industry, the market and the society.

Models of the design process offer a consistent terminology providing a common language for persons from different fields engaged in the design process, and may contribute to the generation of knowledge. Design terminology brings with it, a system of concepts only related to design. As a discipline on its own, design can contribute to the generation of knowledge related both to its own field, and to other fields. Design research follows a similar structure with design practice and aims at understanding a certain problem involving the use of or with the means of an artefact, a building, a system, a service etc., to be created through the design process. Design methodology has made it possible to structure the design process, and this process itself may be considered as a tool that is applied in producing artefacts, and making research. As the design process is structured in a familiar way to other fields that involve science, it has been possible to make research and scientifically assess, categorise, and interpret artefacts that result from the process. The knowledge generated in design research is not only related to the artefacts that are an end result of processes. How the process is carried out, how the designers think and work, how collaboration with other disciplines can take place, and how the process is structured towards efficient results are only some among the topics of design related knowledge. Others would be skills and techniques for production, presentation, and knowledge on materials, used for the production of artefacts and for the production process. This knowledge, although generated through design, is not only related to design and only in offer to designers, but is also related to and offered to the service of other disciplines.

5.4. DESIGN PRACTICE AND DESIGN RESEARCH AS KNOWLEDGE-GENERATORS

As there are areas of knowledge and ways of proceeding special to design, there should then be ways of building knowledge that are specific to design. The construction of the questions asked and a synthesis of the answers, determine decisions that undermine the design process' contribution to knowledge, and how this knowledge can be applied. These processes of knowledge using and knowledge building are controlled by channels that direct the procedures used in doing and judging the work (*Figure 5.4.1.*), which are systems of conventions and rules specific to operate disciplines, developed empirically as 'ways of knowing' as the disciplines have matured. These channels may be borrowed or adapted from other disciplines, though design has evolved its own specific channels (Owen, 1998).

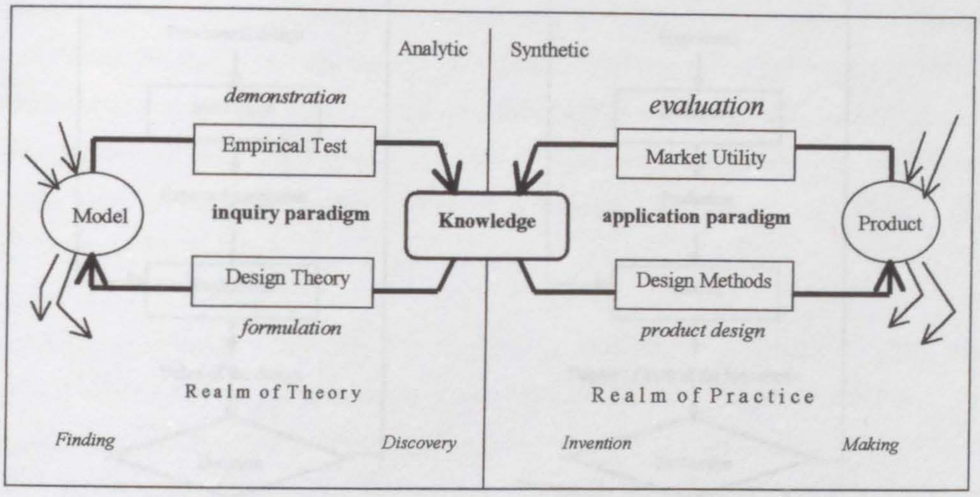


Figure 5.4.1. Realm of Theory and Realm of Practice in the discipline of product design through related procedural channels (Owen, 1998: 15).

At this point, Roozenburg and Eekels (1995) stress the distinction between design practice and design research. The design process leads to material systems with certain characteristics which contribute to solving practical problems. Scientific research is done to solve theoretical problems, such as in situations where the systems created through design do not behave in the expected ways, and must be understood why. Design and research, pursuing different processes, thus require different methods (*Figure 5.4.2.*). The basic cycle of empirical scientific inquiry is based on de Groot's empyrical cycle, discussed in *Section 4.1.*, characterised as a cycle of problem-solving activity: *observation-supposition-expectation-testing-evaluation.*

Roozenburg and Eekels (1995) compare the two cycles as follows: The purpose of the design cycle is to change the world, whereas the purpose of the research cycle is to gain knowledge about the world. The design cycle describes a systematised form of action, through a process that is roughly directed inside-out, from the mental domain to the external domain, towards making changes in the external world. The scientific research cycle is a systematised form of knowledge acquisition, where the process is roughly directed outside-in, towards obtaining mental images of states and patterns of relations in the outside world. In the design cycle, technology plays the important part, and science has an attending role. In the research cycle, science plays the leading role.

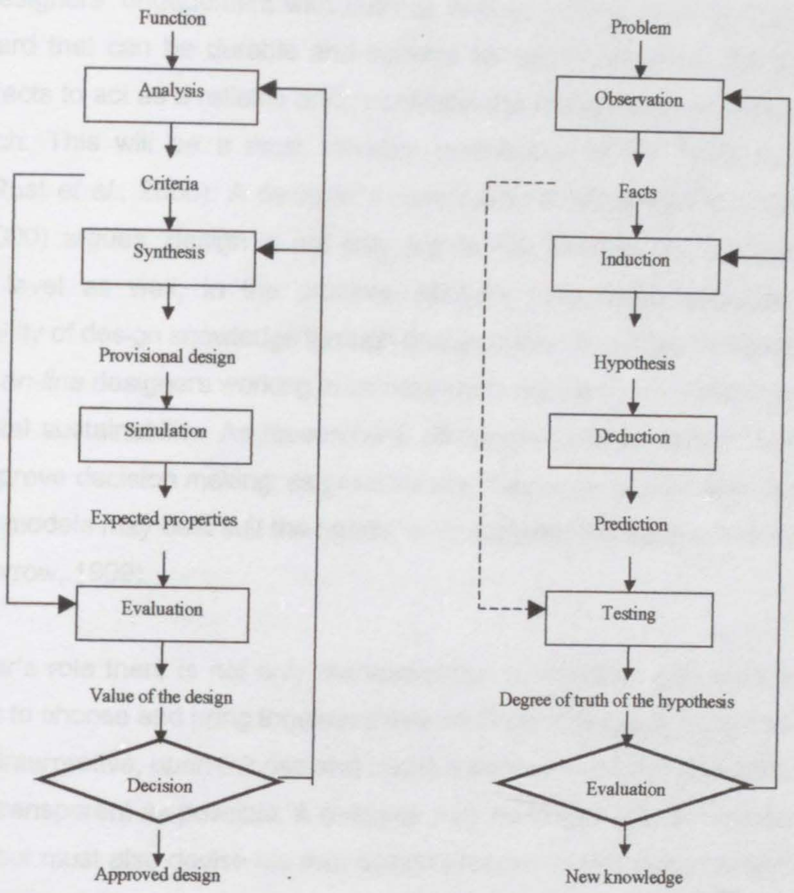


Figure 5.4.2. The basic cycles of design and empirical scientific inquiry (Figure from Roozenburg & Eekels, 1995: 115).

5.5. THE ROLE OF THE DESIGNER WITHIN THE DESIGN PROCESS

A main issue that emerges in the realm of design is the role of the designer. Is the designer merely a tool in the application of the design methods, only acting as a systematic decision-maker? The role of the designer is not merely to make decisions, but also to offer creative and intuitive skills. Methods have been devised to make this process of creative thinking easier for the designer, by organising and guiding the designer through activities of thinking (the methods related to the ways of the thinking process have already been discussed as being divergent and convergent in *Section 2.5.*). Even though it may not be possible to force thinking into predetermined routes, the methods serve by offering guidelines into breaking the personal obstacles, prejudices, and insecurities.

The open-mindedness that the methods have tried to encourage, has also been a necessity as a result of the changing role of the designer. Design has become a team work, and the stamp of the identity of the designer working individually has been replaced by *collective control* over the designers' activities (Jones, 1980). This means that the design process had to become more open to inspection and critical evaluation, and the designer has to be open to the ideas and values of others in this team.

With the designers' engagement with making, and so having skills of producing prototypes of high standard that can be durable and suitable for experimentation, the designer will provide model artefacts to act as a reliable bridge between the mutlidisciplinary communities engaged in the research. This will be a most valuable contribution of the designer to multidisciplinary research (Rust *et al.*, 2000). A designer's contribution is not limited to only making though; as Manzini (2000) argues, design is not only a practical process, but designers may work on a theoretical level as well, in the process. Manzini calls these designers who ensure the generalisability of design knowledge through design research, *off-line* designers and believes that *off-line* and *on-line* designers working in collaboration can 'design the future' to ensure social and environmental sustainability. As researchers, designers must be able to build process models that may improve decision making; as practitioners, they also must be able to determine which of the existing models may best suit the needs, or to suggest how such a model may be developed (Smith & Morrow, 1999).

The designer's role then, is not only the application of methods and procedures in the design process, but to choose and bring together these methods to suggest models for the process, and to follow an interpretive, open-minded and creative approach in their application, and to make the process as transparent as possible. A designer may no longer only be concerned with the act of designing, but must also devise his own design process model, integrating the multidisciplinary or discipline-specific knowledge, tools and skills in a foresighted manner. In this way, whether engaged in practice or research, the designer may contribute to the generation of design knowledge.

5.6. THE ROLE OF THE USER WITHIN THE DESIGN PROCESS

Most products are developed to assist a user in the betterment of a situation, be it leisure or work. Therefore, products such as artefacts or objects in the hands of the user have to be suitable by measures, understandable as to their function and use, and to their purpose and meaning. Designers working in collaboration with human factor specialists, social scientists, and market researchers must study human conditions to understand the users. Products as commodities are made for different user groups such as of specific age, gender, culture, background, interest, profession, special needs, and are determined through market research, research on behavioural sciences, human factors, etc., this diversity of approaches comprising one aspect of the *interdisciplinarity* of the design process. Thus the product-user relationship does not take place under anthropometric or physiological conditions only, but is also on a psychological and sociological basis, and involves matters such as: how the operational information is presented to the user, how this information may be interpreted, and the aesthetic and symbolic nature of the product (Mayall, 1966). To conclude, a product must relate to the (emotional and rational) appeal of the user/client as well as integrating the user's needs, demands and wishes with the design features. The user who is thus involved in the design process in technical, functional and conceptual terms, must be integrated in the design process at three stages.

Research on the User: *Who/How is the User?*

This information is contributed by human factors data obtained through testing methods and anthropometrics. Sciences such as psychology, sociology, cultural studies, humanities, statistics, medicine, etc., also play a role in understanding the user group for which the product is designed. The first stage is concerned with statistical, descriptive and behavioural information on the user.

Research on the User-Product Relationship: *How Does the User Use the Product?*

The user-product relationship takes place before the mass production and launch of the product into the market. Apart from determining issues such as safety, comfort and use related to the product, this stage is when it can be understood whether the user is 'pleased' with the experience the product provides (Hanington, 2000). The performance of the product is revealed, and the connection the product makes with the user in a physical, personal, social and cultural way, is observed. These help in identifying physical capability - 'does this fit in the hand of the user?' - and cognitive understanding - 'is it evident which button to press?' - (Hanington, 2000: 65). The user contributes to this stage by revealing own performance in experiencing the product to assess its performance. Case studies of previous examples of similar design situations also help gathering information with the experiential history they offer: what was done before, for that user group; why did it or did it not work; what has changed since then product-wise and user-wise?

Research on the Client: *Who Buys This Product?*

Research for this stage is concerned with a product after its release into the market. The interest in a product can be determined by the quantity purchased. The user contributes to this stage by purchasing the product, and actually using it in a real life situation. This reveals the success and shortcoming of a product, not only in technical, but also in personal, social, commercial and environmental terms. At this stage, a client profile can be prepared to understand who buys the product, and whether it is used under the circumstances it was intended to be. The life-cycle is observed. If there are maintenance problems, ideally they are eliminated with technical service.

Rust *et al.* (2000) define practice-based research, as personal engagements with users, through the use of real artefacts. The user-product relationship is an investigation through various complexities, depending on the scale of design (Foque & Lammineur, 1995). Hasdogan (1996) discusses the role of *user models* to assess user-product relationship within this complex system. A user model is 'any representation of the potential user created by or available to the designer, to assist the designer in making predictions about the actual user' (Hasdogan, 1996: 20). User models can be *empirical* – such as tabular information, anthropometric recommendations or computer graphics human models. They can also be *experimental* – representative user models, self-modelling of the designer, user interface simulations, virtual reality and participant users. Finally, user models can be *scenario-based,* such as accident scenarios, mental models, user profiling, misuse and abuse scenarios, scenarios on secondary usage, scenarios on people with special needs, on user's level of experience, least competent scenarios, scenarios on third parties, worst case scenarios and evolutionary scenarios.

With these gathered data, designers prepare models with which to investigate the user-product relationship (Hasdogan, 1996). *Physical models* represent the dimensional and mechanical characteristics of the human body. *Cognitive models* represent the human's sensory and cerebral processing system, characteristics and limitations, related to the elements of the system and the outcome of such processes. *Consequence models* represent undesired outcomes from a user-product interaction such as accidents, errors, discomfort, health hazards etc., which decrease overall performance. *Psychosocial models* represent emotional, habitual and cultural characteristics of the users that include psychological and demographic models of market researchers. Torrens (2000) suggests that to overcome limited experience and knowledge of different user groups, apart from techniques of gaining information on user profiles through observations, questionnaires, surveys, interviews etc., designers can use *artificial impairments* (frosted glasses, clothing restricting movement, etc.) to simulate the special situations of a user group and understand the handicaps this brings to the user-product relationship. Finally, McDonagh-Philip and Denton (1999) discuss the use of *focus groups* in evaluating a particular user group's impressions and opinions of existing products.

All this information and the use of models as suggested, require their integration into the design process. This information is not only related to the analysis stage where information on the problem and on the user are gathered, but must extend into the synthesis and evaluation stages as well, though involving social sciences in the process is perhaps still confusing for the design team who has to cope with knowledge and skills from such diverse fields. Information related to the actual users may require more emphasis for certain products, and there seems to be a lack of examples of design models reflecting the involvement of and encouragement for the integration of users within the totality of the design process.

As a concluding remark to *Chapter 5.*, we may state that, design is a wide ranged multidisciplinary process, encompassing and generating a large body of knowledge. It is a process of a total endeavour, in terms of the knowledge and techniques it requires, controls and generates. Yet in it, there still is an element of individuality and creativity that distinguishes it from the other fields, mainly manifested in the agent of the designer him/herself and in the human needs of the user/client. A design process model must therefore guide the process systematically to eliminate the risk of randomness, error or waste of resources and time; all the same, making it possible for the designer to interpret the model according to the needs of the design situation, integrating the creative and intuitive skills of the designer, and the human needs of the user in particular. The original contribution of the designer to the generation of design knowledge can hence be achieved. Design thus stands out as a discipline in its own rights, the designers applying design-related knowledge and skills to attain products and also, towards the generation and organisation of further knowledge and skills.

6. THE DESIGN PROCESS REINTERPRETED FOR THE PROPOSAL OF A DESIGN PROCESS MODEL TOWARDS A SPECIFIC PRODUCT FOR A SPECIFIC USER GROUP

In the *Chapters 2., 3.,* and *4.,* design, design methodology and design models were discussed extensively; in *Chapter 5.,* certain important issues derived from the previous discussions, were pulled forth and further discussed to arrive at a clear understanding of the basic crucial points that will help construct a design model proposal with which to conduct a design process towards a specific design task. In this chapter, discussions will be carried out towards the construction of this model. The design task to be undertaken is: developing an educational toy for blind and visually impaired children. The design process begins with the arrival of this design task. The design process being multisdisciplinary, has to encompass and control a wide range of information, knowledge and skills. This design problem will involve knowledge on child development and psychology in general, and related to blind and visually impaired children in particular; educationally acceptable norms of toys; toys specific to blind and visually impaired children so far offered; market information on toys in general and on toys for the sensory impaired; predictions as to present and potential user demand; the toy making industry; techniques employed, advanced techniques that may be available, and knowledge of suitability, safety, appeal, etc., of materials, design features and production techniques for mass-produced toys.

Design being a discipline that collaborates with research and in turn generates knowledge, this design task will require research in depth. The body of knowledge that has to be gathered to be input at various stages during the design process is extensive, particularly for a design task of this nature, which is very user-specific, and which needs a well-founded base to end up in a novel product, as this type of toy is not very commonly available, and innovation in this field would be welcome. This design process with all the research data and other information at its control, will simultaneously be agent to the generation of further knowledge around this subject; particularly at the field testing stage. The user is an important factor in the design process, as the extent of research on the user will illustrate. The testing stage is where the user once again will assume a central role.

To minimise the risk of randomness in the design activity crucially important in this particular design task, a model derived from design methodology will structure the sequence of the related activities. The designer, the agent in the devising of the model, will decide where to strictly abide to or slightly deviate from or iterate through the phases of the model. In other words, the designer will co-ordinate and orchestrate the knowledge, information, skills, and the model, while conducting the design process. Before building the model, a structural framework will be presented, as a representation of the design process envisaged (*Figure 6.1.1.*).

6.1. PROPOSING A STRUCTURAL FRAMEWORK FOR THE DESIGN PROCESS

The arrival of the design task as input, triggers the analysis phase of the process, where the design problem is defined, the design strategy is determined, and research is carried out to understand and investigate the problem. The analysis phase produces as an output, the *problem specification*, which is the input of the synthesis phase. In this phase the design programme is established, ideas are generated according to the *design specifications*, a final idea is selected from among these alternatives as the *final concept.* The actual designing activity is carried out to give form to this concept, and the *final design decisions* are made. The design is represented in 2-D and 3-D communication techniques, and the *prototype* is manufactured accordingly. The synthesis phase is where the ideas are brought together into a whole, towards the expression of a product. The output of this phase is the *prototype.* The phase of evaluation is where this prototype is tested and evaluated. The prototype is tested for performance and for user group reaction and interest. This helps in the evaluation of the product, to be able to foresee its market and function success, also to be able to suggest necessary corrections and modifications through revisions. With these suggestions, *refined and finalised design decisions* are obtained. The product is mass-produced. The output of this phase is the *produced product.* Yet, the process also manufactures a design model that is shaped through the predetermined design strategy. Ideally, the evaluation stage must also involve the evaluation of the entire process, such as whether the project was carried out to time, within determined limits, according with the problem and design specifications, etc. As a result of this evaluation, it will also be possible to correct and modify the design model employed, to be able to offer it for future reference, and for interpretation and use in design tasks of a similar nature.

Points of *communication* and *control* are recommended within the process to check the moments of critical decision making, also to ensure that parallel activities carried out such as management, marketing and production processes are in interaction with the design process. Communication of the ideas with the user group is made to ensure that the ideas generated and represented in models are suitable to the requirements or needs of the user group. Such an exchange of ideas also helps to further finalise decisions on design details. If there seems to be incompatibility within this interaction, then certain decisions must be revised, on the problem definition, research, the design problem and the ideas that are generated, until alternatives may be refined and represented. Once the final concept is selected, it must be presented this time to the managing, production and marketing teams to ensure communication, distribution of teamwork and exchange of opinions to further develop the design. It is recommended that *control* takes place during the actual designing of the project, to ensure correctness and quality in the design work carried out. Control may also take place during the manufacturing of the prototype and production of the product to ensure correctly made material, tooling and production decisions.

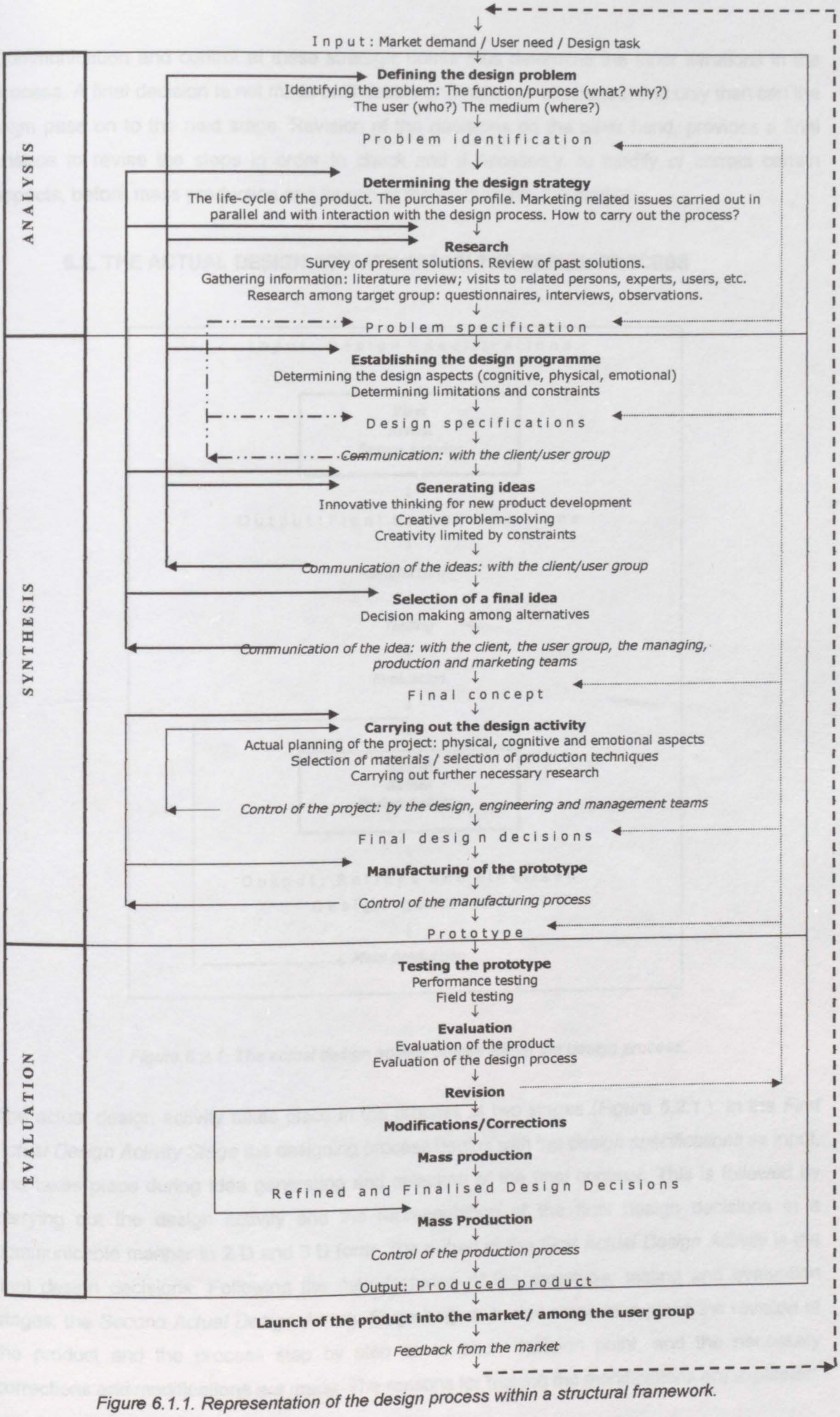


Figure 6.1.1. Representation of the design process within a structural framework.

Communication and control at these strategic points thus determine the inner iterations in the process. A final decision is not made until doubts and risks are eliminated, and only then can the team pass on to the next stage. Revision of the decisions on the other hand, provides a final chance to revise the steps in order to check and if necessary, to modify or correct certain aspects, before mass production and launch of the product into the market.

6.2. THE ACTUAL DESIGN ACTIVITY WITHIN THE DESIGN PROCESS

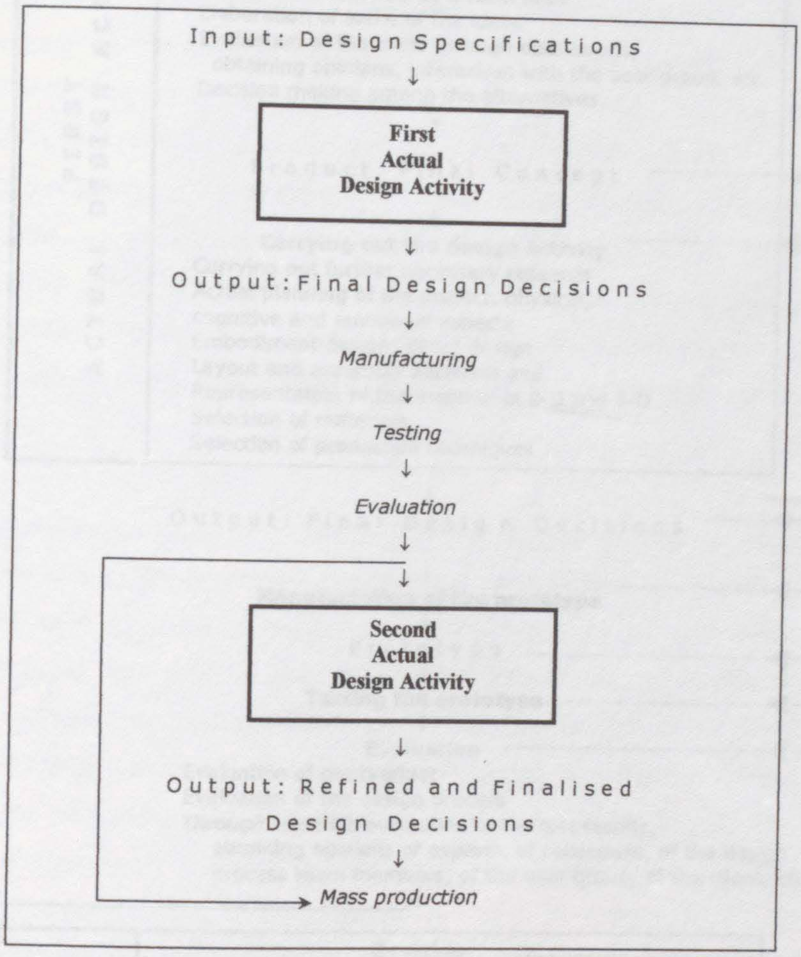


Figure 6.2.1. The actual design activity stages within the design process.

The actual design activity takes place in the process at two stages (*Figure 6.2.1.*). In the *First Actual Design Activity Stage* the designing process begins with the *design specifications* as input, and takes place during idea generating and selection of the final concept. This is followed by carrying out the design activity and the representation of the final design decisions in a communicable manner in 2-D and 3-D form. The output of the *First Actual Design Activity* is the final design decisions. Following the manufacturing of the prototype, testing and evaluation stages, the *Second Actual Design Activity Stage* begins. In this stage take place the revision of the product and the process step by step as to each decision point, and the necessary corrections and modifications are made. The reasons for making the modifications are explained.

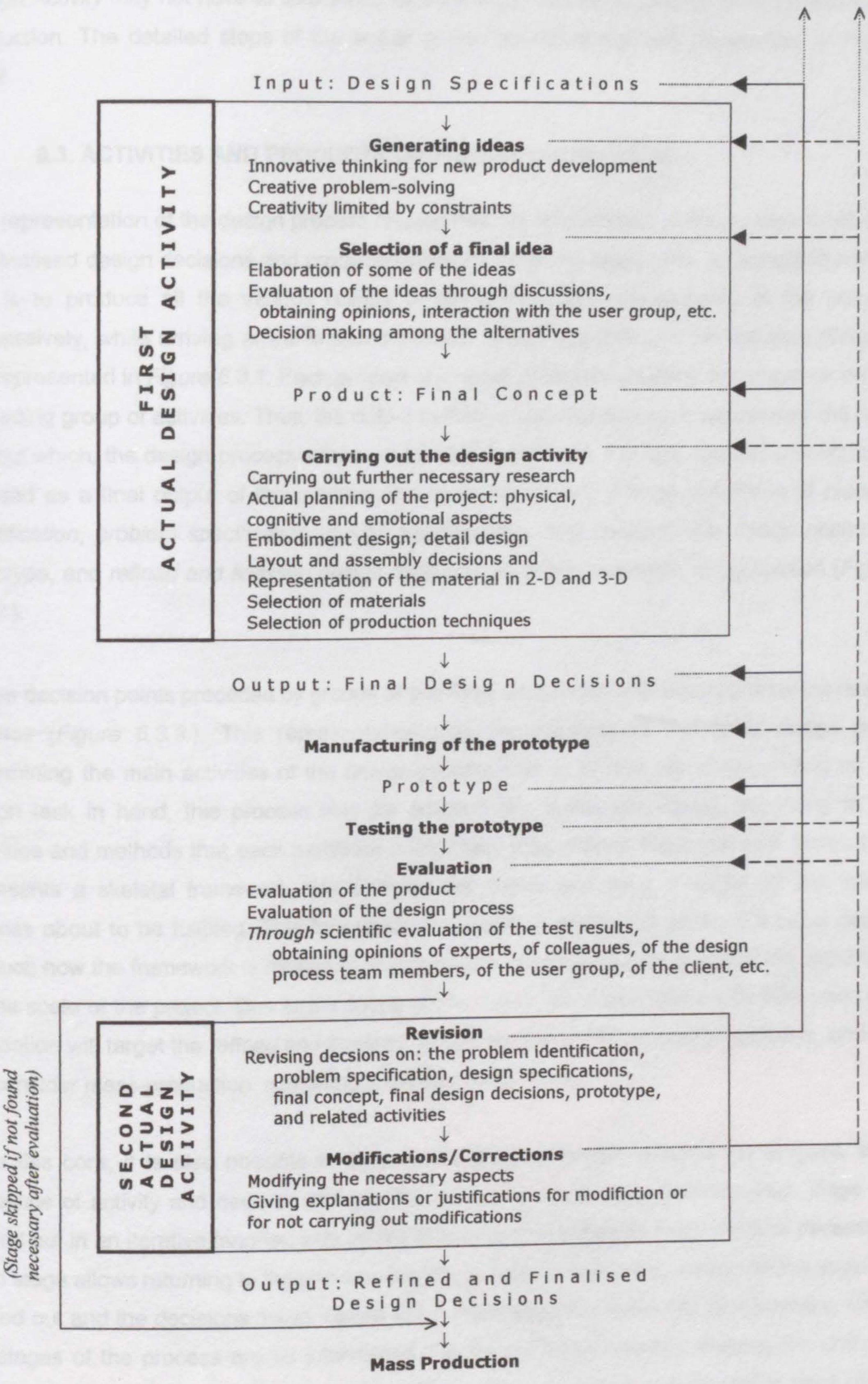


Figure 6.2.2. The steps of the actual design activity stages within the design process.

If the modifications will not be made, justifications are made as to the reasons. These may be related to aspects such as economic limitations, time restrictions, policy of the company.

Depending on the test results made towards the evaluation of the product, the *Second Actual Design Activity* may not have to take place, and the stage can be skipped to continue with mass production. The detailed steps of the actual design activity stages are represented in *Figure 6.2.2.*.

6.3. ACTIVITIES AND PRODUCTS OF THE DESIGN PROCESS

The representation of the design process reveals that the sole product of the process is not only the finalised design decisions and produced product. It may be argued that an equally important aim is to produce all the various results of the diverse strategic activities of the process successively, while arriving at the finalised product. These activities and the resulting products are represented in *Figure 6.3.1.* Each product is a result of decision-making, and depends on the preceding group of activities. Thus, the output of each group of activities is the input for the next, without which, the design process would not be able to continue. For a successful product to be realised as a final output of the process, the decisions on and precise definitions of *problem identification*, *problem specification*, *design specifications*, *final concept*, *final design decisions*, *prototype*, and *refined and finalised design decisions*, must be undertaken in succession (*Figure 6.3.2.*).

These decision points preceded by groups of activities, thus determine new stages for the design process (*Figure 6.3.3.*). This representation may be specified as the *basic design core*, determining the main activities of the design process that must take place. Depending on the design task in hand, this process may be adapted into a relevant model, according to the activities and methods that each particular design task may require. From this core then, which represents a skeletal framework, the designer will derive and build a model for the design process about to be fulfilled. This foundation framework is defined to produce a basic design product; how the framework is related to business and marketing issues is a concern depending on the scale of the project. Due to the scope of the thesis, the model that will be built upon this foundation will target the *refined and finalised design decisions* through design activities, and will not consider mass-production, marketing and managerial issues.

From this core, it is also possible to observe the developmental nature of the process, as a sequence of activity and decision making. The activities taking place between each stage are carried out in an iterative manner, with cycles of activities repeated as many times as necessary. Each stage allows returning to the previous stages, in order to check and reconsider the activities carried out and the decisions made. *Figure 6.3.4.* represents this spiral-like development, where the stages of the process are all interrelated. As the process proceeds, towards the end, the activities become more diverse, many taking place at the same time and parallel to each other, and the decisions become more condense and interdependent with previous and successive decisions.

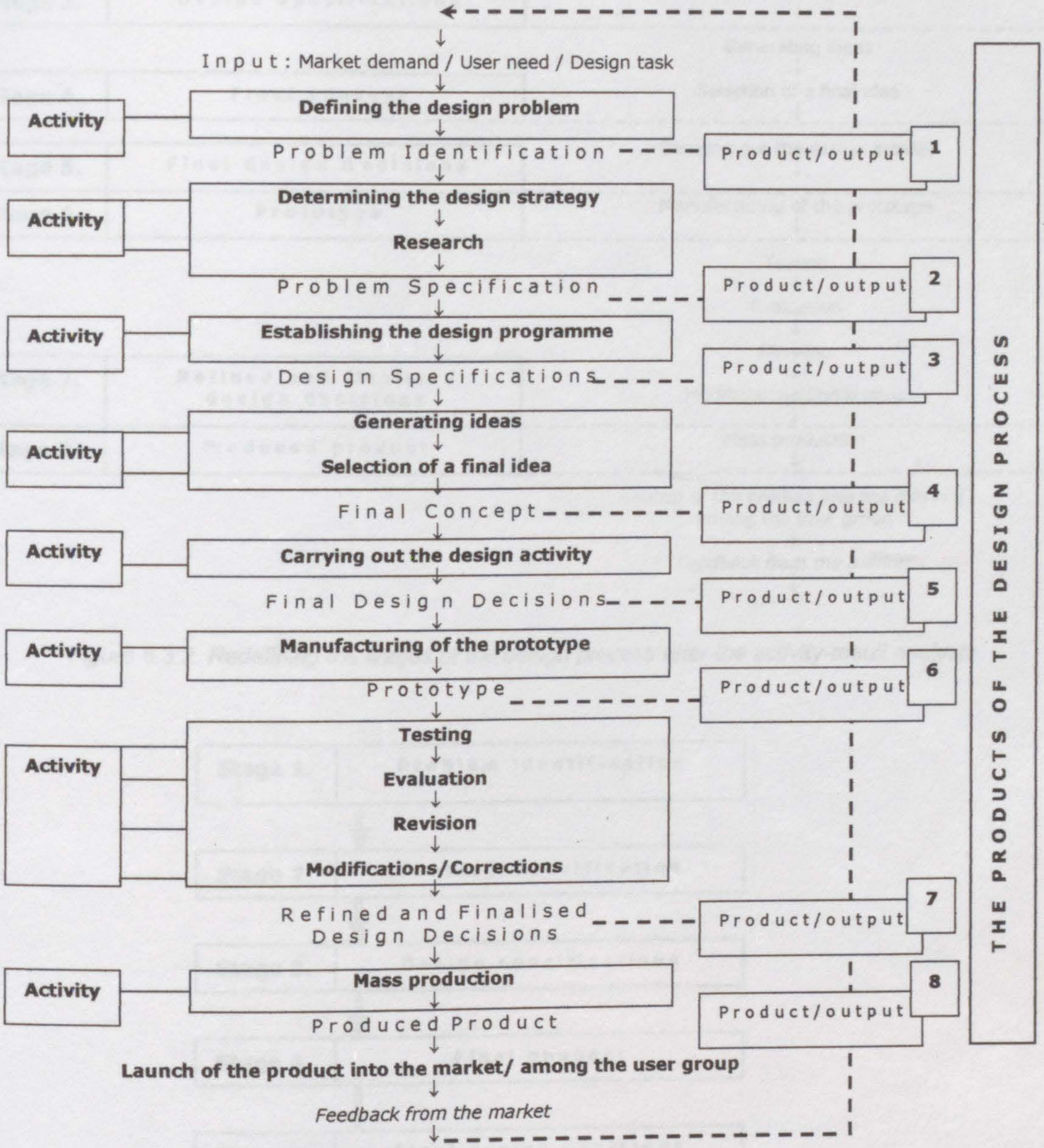


Figure 6.3.1. The activities and products of the design process.

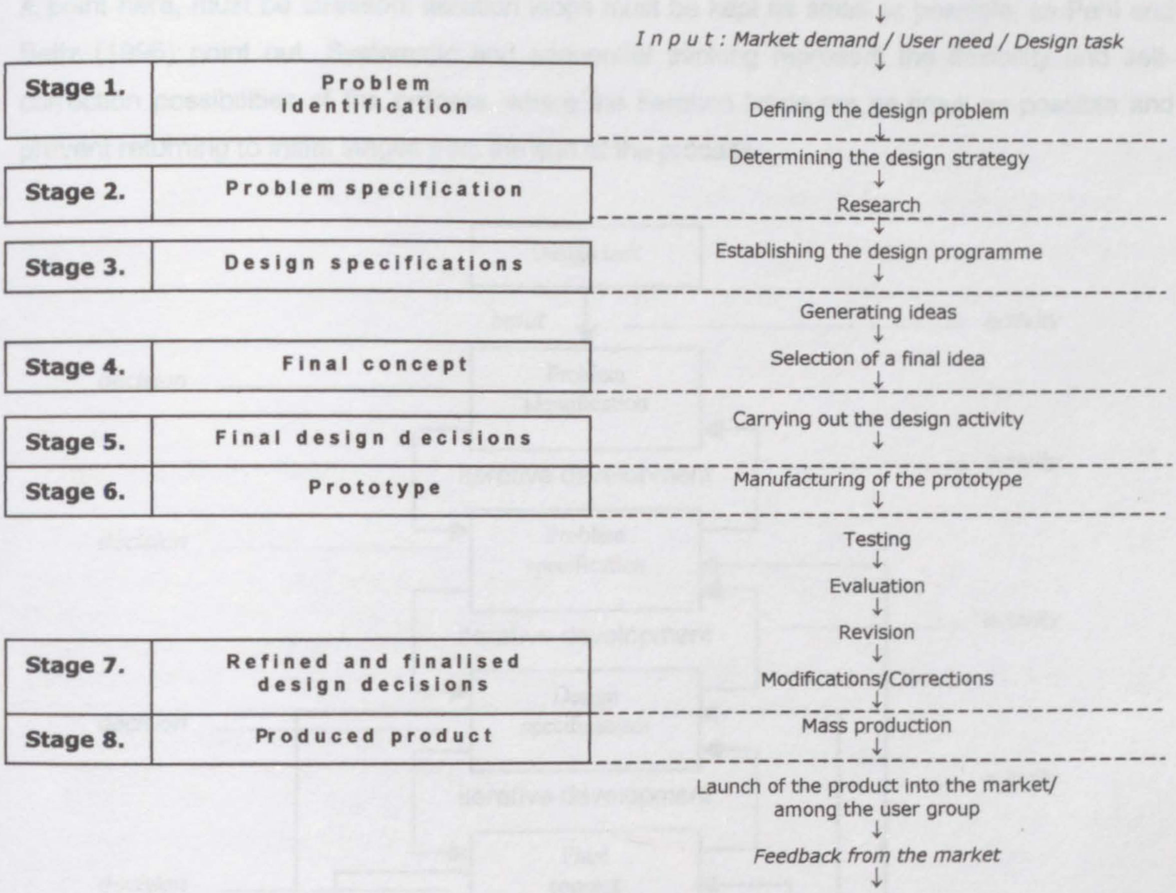


Figure 6.3.2. Redefining the stages of the design process after the activity-result analysis.

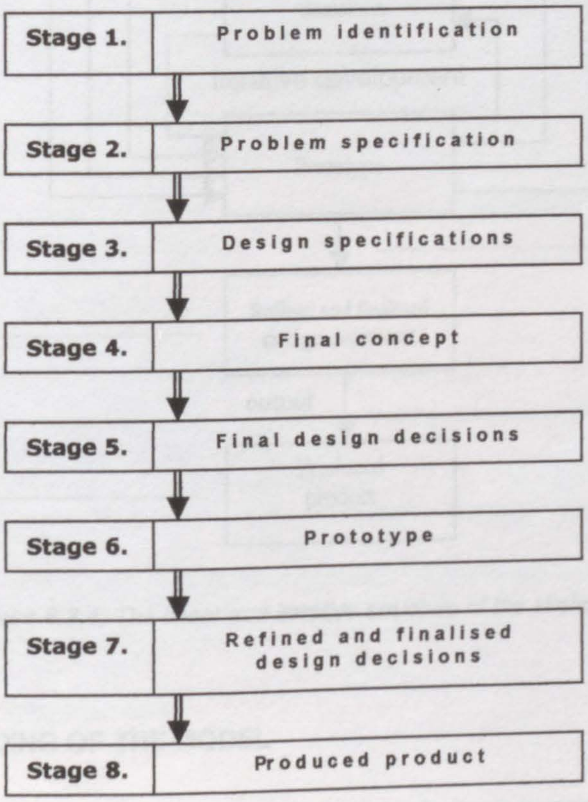


Figure 6.3.3. The core of the design process open for adaptation to different design tasks.

A point here, must be stressed; iteration loops must be kept as small as possible, as Pahl and Beitz (1996) point out. Systematic and sequential thinking represent the flexibility and self-correction possibilities of the process, where the iteration loops are as small as possible and prevent returning to initial stages from the end of the process.

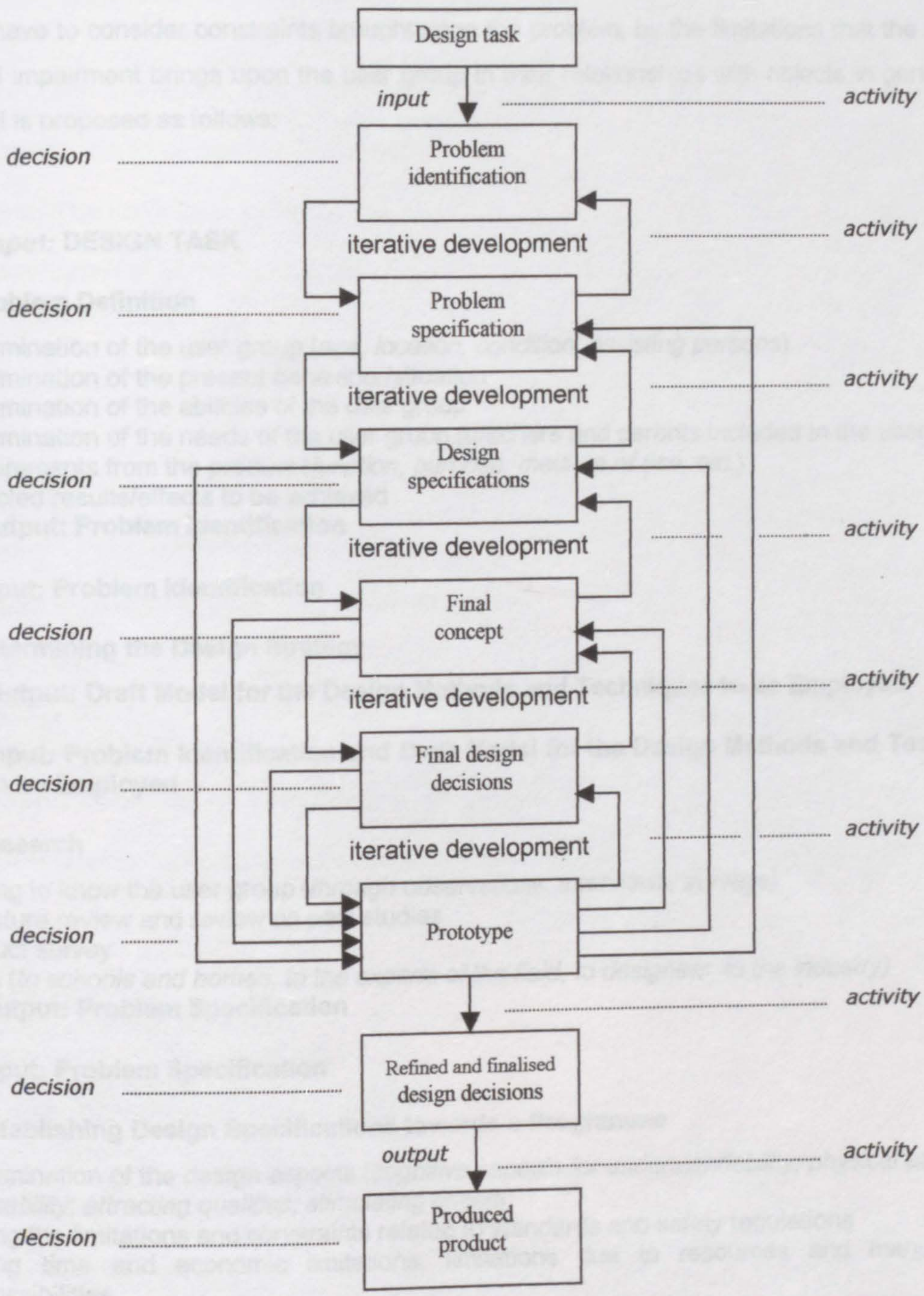


Figure 6.3.4. The linear and iterative structure of the skeletal framework.

6.4. BUILDING OF THE MODEL

As the core of the design process is now ready to be built on, a model framework will be devised to design a product for visually impaired children, as was stated at the beginning of the chapter.

While the design task is determined, the problem is not yet fully identified. The model will therefore aim at following a systematic procedure for problem identification, and for developing a novel concept in particular. A creative approach will also be necessary, based on research for a deep understanding of the situation in hand, the behaviour of the user group, and in what direction a concept should be developed in answer to their demand. This creative approach will also have to consider constraints brought upon the problem, by the limitations that the nature of visual impairment brings upon the user group in their relationships with objects in general. The model is proposed as follows:

↓

***Input:* DESIGN TASK**

1. Problem Definition

Determination of the user group (*age, location, condition, assisting persons*)
Determination of the present behaviour/situation
Determination of the abilities of the user group
Determination of the needs of the user group (teachers and parents included in the user group)
Requirements from the product (*function, purpose, medium of use, etc.*)
Expected results/effects to be achieved

Output: Problem Identification

↓

Input: Problem Identification

2. Determining the Design Strategy

Output: Draft Model for the Design Methods and Techniques to be Employed

↓

Input: Problem Identification and Draft Model for the Design Methods and Techniques to be Employed

3. Research

Getting to know the user group (*through observations, interviews, surveys)*
Literature review and review on past studies
Product survey
Visits (*to schools and homes, to the experts of the field, to designers, to the industry)*

Output: Problem Specification

↓

Input: Problem Specification

4. Establishing Design Specifications towards a Programme

Determination of the design aspects (*cognitive aspects for understandability; physical aspects for usability; attracting qualities; stimulating effects*)
Stating the limitations and constraints related to standards and safety regulations
Stating time and economic limitations, limitations due to resources and manufacturing possibilities
Stating limitations and constraints arising from the relationship between the requirements from the product and the capabilities of the user group

Output: Design Specifications

↓

Input: Design Specifications

5.Creation of the Concept

Generating ideas (*discussions, sketching, rough models, critiques*)
Presenting ideas to the user group for immediate feedback
Selecting one alternative that suits most of the design specifications

Output: The Final Design Concept

↓

Input: The Final Design Concept

6. Designing

Refining the design concept through visual communication techniques
Transferring the final design concept into a legible design product
Critiques from and discussions with colleagues
Carrying out further necessary research (*on the user group, safety regulations, materials, production techniques, field testing methodology, etc.*)
Selection of the materials and of the production techniques

Output: The Final Design Decisions

↓

Input: The Final Design Decisions

7. Manufacturing of the Prototype

Output: Prototype

↓

Input: Prototype

8. Testing

Safety testing
Field testing

Output: Data Collected from Testing

↓

Input: Prototype + Data Collected from Testing

9. Evaluation of the Final Design

Evaluating test results and collected data
Interpreting the study
Obtaining opinions

Output: Decisions on Revision

↓

Input: Design Specifications, Concept, Prototype, Draft Model of the Design Process + Decisions on Revision

10. Revision

Revising the concept
Revising the design decisions
Revising the production decisions
Revising the design model

Output: Decisions on Modification

↓

Input: Design Specifications, Concept, Prototype, Draft Model of the Design Process + Decisions on Modification

11. Correction/Modification

Making necessary modifications
Giving explanations and justifications

Output: REFINED AND FINALISED DESIGN DECISIONS

7. IMPLEMENTATION OF THE BUILT MODEL TOWARDS DESIGNING AND REALISATION OF A TOY FOR BLIND/VISUALLY IMPAIRED CHILDREN

INPUT: THE DESIGN TASK (To design a toy with educational objectives for blind/visually impaired pre-school children)

7.1. PROBLEM DEFINITION

DETERMINATION OF THE USER GROUP

The target group of the design task is children of pre-school age (3-6 years) with visual impairments, also depending on the developmental stage of the child. Additional physical and cognitive disabilities and behavioural or emotional problems are to be expected. All other children of pre-school age are secondary targets; a better distribution of the toy among children with special needs would be to make the toy available to all children. People involved, such as parents, teachers, therapists, researchers etc., are also indirectly related to the toys the children play with: they choose the toy for the children and play with them. It would be appropriate that the toy is used at schools, homes, and such indoor environments where the children carry out their daily play.

DETERMINATION OF THE PRESENT BEHAVIOUR/SITUATION

Blind and visually impaired children may have physical and conceptual delays of development, compared to their sighted peers. These delays, generally due to lack of experience with the outer world, should be overcome before children begin formal education. One way of overcoming this is through play. The children, in general passive towards interactions, seldom play with toys in the way adults expect them to. This suggests that the toys available may not be offering the experiences that visually impaired children may find interesting, stimulating and encouraging towards constructive and functional play. This topic must be further investigated.

DETERMINATION OF THE ABILITIES OF THE USER GROUP

Children, though visually impaired and even physically handicapped, will nevertheless have diverse abilities and skills and the toy must permit the use of these abilities and skills with the features that it offers. A starting point may be to stress that the inability of sight must not be the main emphasis of the toy to be designed, but the basis for certain features that may be used as cues to the nature and function of the toy.

DETERMINATION OF THE NEEDS OF THE USER GROUP

The visually impaired child needs to be richly stimulated to gain awareness of his/her own capabilities and to learn how to respond to stimuli. To respond to stimuli, the child will also have to develop certain physical and cognitive skills. To touch and manipulate objects, the child will have to develop fine- and gross-motor skills, be aware of position in space, use posture correctly, etc. To be able to organise him/herself within an environment, the child will need to develop a sense of time and space. To be able to cope with notions and concepts, the child will need to make use of symbolic representation, systematic thinking, creative problem-solving, and imagination. The child will need to develop self-care skills and social skills towards an independent and fulfilling future life.

REQUIREMENTS FROM THE TOY

Through playing with the toy, the blind child should be able to understand that:

- he/she affects objects;
- he/she affects the environment;
- he/she affects other persons;
- other persons affect him/her / objects / the environment / other persons;
- objects affect him/her / other objects / the environment / persons;
- the environment affects him/her / objects / persons;
- the child should also understand the nature of all these possible effects.

The toy should provide these richly stimulating experiences and interesting activities that will also encourage the use of imaginative skills. The toy should offer fun rather than demanding tasks, and therefore must not make the child feel pressurised in achieving these experiences. The child should be able to play with the toy in the way he/she wishes. The toy must be such that the visually impaired child can cope with it both in physical and cognitive terms, and even be helped to show progress in some related skills. Some children will be able to do certain things with the toy, that others will not be able to do. The toy must take account of this possibility and offer flexible play opportunities.

EXPECTED EFFECTS OF THE TOY

As a result of interaction with the toy, it is not expected that a child corrects an unwanted behaviour or improves certain skills, though this may happen to some extent. What is hoped for is that, the child enjoys encountering and interacting with this object, and will be willing to play with it. Nevertheless, there may be cited certain reactions or interest that the toy should evoke. It should be observed whether:

- the child shows interest in the toy as an object, contacting it, and in time manipulating it, and not only playing with it in an exploratory or a repetitive manner;
- the child shows interest in the physical, cognitive and imaginative activities that the toy offers;
- it encourages spatial exploration;
- it encourages socialisation between the child and an adult or a peer.

PROBLEM IDENTIFICATION

The problem is to design a toy that will encourage interaction with the surrounding environment, and that through this interaction, will provide diverse physical and conceptual experiences for blind children, who may be delayed in certain areas of development, due to the nature of the impairment that keeps them passive and inattentive to the ongoing events around them. Among the objectives of the toy will be,

- to encourage physical independence for the child with no sight, providing in the meantime basic knowledge on objects and space, and developing cognitive skills,
- to provide opportunities for the child to use imaginative and creative skills in the play,
- to provide a means of social interaction between the child and adults and the child and peers (blind or sighted).

As summarised above, after a brief literature review on the topic and brief visits to the user group for observations, the task was roughly outlined. This is only an initial layout. The outline of the task is yet tentative and will be refined in the coming stages of the process, through an intense research into the subjects involved.

OUTPUT: PROBLEM IDENTIFICATION

7.2. DETERMINING THE DRAFT MODEL OF THE DESIGN STRATEGY

INPUT: PROBLEM IDENTIFICATION

1. Problem Definition

Brief *literature review* on the topic
Brief visits to the user group for *observations*

2. Determining the Design Strategy

Literature review on design methodology, strategies and models (undertaken in *Chapters* 3., and *4.*)

3. Research

Literature review on visual impairment, the development of the visually impaired child, play behaviour, pre-school education, design related to toys.
Product/market survey (toys for children with special needs; toys for pre-school age children in general)
Visits to homes, to schools, to toy libraries (observations of the user group; interviews and discussions with the parents and teachers)
Visits to experts
Visits to designers, to the industry (observations, interviews and discussions)
Discussions with colleagues and supervisors so as to assess and evaluate the collected information

4. Establishing Design Specifications towards a Programme

5.Creation of the Concept

Idea generation through sketching, making rough models
Visits to the user group to obtain ideas and to make *activity analyses*
Creative thinking through sketching and making models with gained insight related to the ideas
Creativity enhanced with methods such as use of *analogies, making associations, using checklists, analysing functions of previously made products, etc.*
Decision-making aided with methods such as *interaction nets and matrices, morphological charts, elimination by order ranking, etc.*

6. Designing

Refining the design concept through *visual communication techniques* (scaled drawings, computer modelling, rough models, scaled models)
Obtaining *critiques* from and discussions with colleagues
Carrying out further necessary *research*
Research on materials and production techniques prior to their selection (literature review, visits to the industry, visits to model-makers, etc.)
Transferring the final design concept into a legible design product (computer drawings, computer rendering, computer simulations or animations, building of working model and prototype)

7. Manufacturing of the Prototype

8. Testing

Safety testing (*experiments* made in safety testing laboratories, requires research on laboratories and the application of safety tests)
Field testing: *experimental and non-experimental research* (requires research on the subject)

9. Evaluation of the Final Design

Evaluating test results and collected data (requires research on *evaluation procedures* suitable to the experimental or non-experimental research conducted)
Obtaining opinions from experts, from parents, teachers, and designers

10. Revision

Revising the concept,
Revising the design decisions,
Revising the production decisions,
Revising the design model, all through *discussions, checklists, comparisons with similar toys available in the market and used by the user group, comparisons with the design specifications, comparisons with the needs and requirements of the user group, comparisons of other generated ideas using weighting charts, order-ranking, etc.*

11. Correction/Modification

Making necessary modifications through scaled drawings and models
Giving explanations and justifications

OUTPUT: PROBLEM IDENTIFICATION AND DRAFT MODEL FOR THE DESIGN METHODS AND TECHNIQUES TO BE EMPLOYED

7.3. RESEARCH

INPUT: PROBLEM IDENTIFICATION AND DRAFT MODEL FOR THE DESIGN METHODS AND TECHNIQUES TO BE EMPLOYED

7.3.1. RESEARCH TOPIC I: THE DEVELOPMENT OF THE BLIND/VISUALLY IMPAIRED CHILD

Keeler's (1958; cited in Fraiberg, 1977) analysis of the development histories and behaviour patterns of blind children, indicates that the gross abnormalities encountered in certain blind children may be associated with total or nearly total blindness from birth and a history of inadequate emotional stimulation in the early months of life. Reynell's (1978) study shows that until 10-12 months, blind and sighted infants may not demonstrate immense differences, but after that, blind children should be assisted to speed up development. However quickly these children find intellectual means to overcome the difficulties of having no vision, they are likely to be one or two years behind sighted children in most aspects of learning. Yet, unnecessary limitations are too often placed upon the blind child because of unrealistically low expectations which may prove to be a serious hinderance to development (Norris *et al.*, 1957), and the blind child's signs of readiness for further experiences may thus be missed.

Fraiberg (1977: 8) claims that stimulus deprivation in early development can be one aetiology of autism for both the sighted and the blind: 'When blindness, which constitutes a central form of stimulus deprivation is united with deprivation in tactile, kinaesthetic and auditory experience, a state of extreme deprivation may exist which threatens ego development.' In a number of cases, autism with a presumed cause of early sense deprivation in young blind children has been successfully treated through enlarging and enriching the experiences of the blind child with his mother.

According to Fraiberg (1977: 8), under-stimulated totally blind young children may have no sense of a body and other 'something out there'. Hands are not used for exploratory behaviour; they serve only to feed the mouth with the sucking of an object, and the child is mouth-centred. For audition-based object constancy for infants as young as 6 months, the infant has no visual information to match, and cannot understand verbal explanation. Yet object constancy may develop for objects that 'occupy positions of extreme importance' (such as the milk bottle), and for those the infant has received prior tactual information.

ACHIEVEMENT OF THE OBJECTS CONCEPT AND THE ONSET OF LOCOMOTION

Fraiberg closely relates the blind infant's physical development with his/her cognitive development. The use of hands play an important role in contacting and exploring the external world. Although around 5-6 months, the blind infant has a fair to good control of head at midline position, hands are maintained at shoulder height in the neonatal position. Empty hands may occasionally make grasping-ungrasping motions and are generally maintained fisted while at rest (Pogrund *et al.*, 1992). Midline organisation and co-ordination of hands are important, and should be encouraged through bringing hands together at midline (Fraiberg, 1977). At 9 months, the blind baby will be employing index finger to explore holes, but his/her grasping and clutching is clumsy, and will not use the thumb and forefinger to pick up. He/she may not be able to use both hands to hold two different things, and to make transfer (Fraiberg, 1977). In the course of the first year, the hand is an organ for maintaining contact and later for fine discrimination. Also, flickering of fingers and grasping and ungrasping motion of the hands can be observed when sound occurs. The blind infant does not yet reach for a toy that can make sound, though placed very near, or search for it when it is taken away.

Fraiberg (1977) suggests that a blind infant does not reach to sound cues because there is no mental convergence of the sound of a familiar toy with the infant's memory of it. Until towards the end of the first year, the blind baby may not yet attribute substantiality or a sound-touch identity to the toy/object/person through its sound alone. Mother's voice and touch are familiar, but they do not yet belong to a unique item for the infant. Around 10-16 months, babies demonstrate proximity-seeking behaviours towards the mother's voice. The mother has now acquired a voice-touch identity (Fraiberg, 1977).

Sound cues alone do not confer substance to an object. Just as vision provides a sighted infant with a clue to an object's permanence, it is the tactile not the auditory qualities of an object that initially provide this clue to a blind infant (Dunnett, 1997). Fraiberg (1977) notes that blind infants do show evidence of object constancy when the object is experienced tactually: by about seven months, they will reach out in search of the object if it is removed from their hands. Yet, the development of object permanence may be delayed until 3-5 years of age. Fraiberg (1968; cited in Lewis, 1992) explains this as resulting from giving up search for an object if it is not found and as the child may believe it no longer exists. Scott (1969; cited in Warren, 1984) explains this as:

- Limited range of environment which the blind infant can know and experience directly
- Part of environment within reach not having the same stimulus value for the blind child that it has for the sighted
- Limited appreciation of his/her impact upon objects, which he/she manipulates.

On the other hand, Ross and Tobin (1997) argue that, although lack of vision may delay the acquisition of exploratory behaviour, it is not evidence to believe that infants who are blind do not know that objects exist unless in direct physical contact with them. Blind infants may be aware that objects exist because they can hear the objects, but they may be less likely to ascertain anything about what *value action* the objects may afford. Furthermore the effort that infants expend attempting to interpret sounds may actually inhibit motor behaviour. As sounds are not continuous, it will be difficult to understand that objects continue to exist when they are not being experienced.

Fraiberg argues that the delay of the blind child in reaching for an object is conceptual, but Hart (1983, cited in Lewis, 1992) suggests it is of a motor basis. She suggests prone positioning to encourage and improve motor activities. Nielsen (1979) remarks that blind children often have a poorly developed control of head movement, and finds it useful to encourage prone position, since this is the first position in which the infant holds the head up. This position may also encourage the child to raise him/herself on hands and knees, and in time to crawl and become mobile. Yet, it is observed that blind children dislike lying prone and thus do not build up the muscle strength and co-ordination of arms, chest and shoulders necessary for reaching (Dunnett, 1997). Fraiberg (1977) cites in her study, instances where an infant had for weeks been able to support himself on knees and hands, yet had not crawled forward. This is achieved after the onset of reaching for sound, late in the first year (Warren, 1984).

Fraiberg (1977) suggests that by enlarging and expanding the baby's tactile-auditory experience, in time he/she will begin to tactually explore, recognise and even show preferences among objects. The blind baby's experience of each object will be sequential and much slower than the sighted child's visual experience (Ross & Tobin, 1997). It will be much more difficult for the blind baby to understand the total extent of many objects, and to relate one part of an object to another part. When the infant is given objects, he/she experiments with them, listens to the sounds they produce, and in time learns to create voluntary sounds with objects. The same objects placed in different places teach that an object can be displaceable (Fraiberg, 1977). The blind infant has to be introduced to and not just handed objects in order to encourage reaching and grasping behaviour. The behaviour of reaching of a visually impaired baby will be around 10-11 months, or even later. Yet, this would be similar for sighted babies if their eyes were covered, and expected to reach for a toy by its sound.

Reaching towards sound is a sign of the achievement of object permanence for the infant. Once he/she knows the mother can be found because she is an existing object, *separation anxiety* is observed. Fraiberg (1977) suggests this is what triggers the onset of locomotion. If not skipped, crawling will be around 10-16 months, free walking around 12-20 months. According to Fraiberg then, the development of object permanence and the onset of locomotion and language development take place in the following sequence:

Awareness of loss of contact with mother
Distress
Tracking and locating mother on voice or sounds of movement
Following
Accounting for mother as a displaced object
Diminution of distress
Use of language to locate and to keep in touch with mother

MOBILITY

Giving environmental and emotional opportunities to independent movement would prevent extreme delays. Children should be encouraged into physical interaction with the environment and with friends, to develop a stronger, healthier body, to help better oxygen intake and not to become overweight or remain too small (Pogrund *et al.*, 1992). Some movement and postural characteristics observed in blind children (Pogrund *et al.*, 1992) due to limited physical experience may be as follows:

- Maintaining head forward and down, or back
- Holding shoulders rounded forward, elevated or retracted
- Using a wide base for sitting, spreading legs apart for balance while standing
- Walking, moving awkwardly from one position to another
- Using a variety of gait patterns.

Once the blind child has shown the ability to pull up to stand, he/she should be encouraged to be independently mobile. One way may be using mobility devices, though not all of these devices have been proved to be safe and useful, such as jumpers and walkers. Besides, their constant use may inhibit development of normal motor patterns and balance, and decrease opportunities for creeping and crawling (Clarke, 1988; cited in Pogrund *et al.*, 1992). Lewis (1992) and Fraiberg (1977) do not encourage the use of walkers.

Toys, on the other hand, can be used for support or some protection, and to provide initial movement experiences in conjunction with a sighted person, as transitions from sighted guide to independent movement as distance increases (Pogrund *et al.*, 1992). These may be push-toys, hula-hoops, rubber rings, broom handles, large balls to be rolled, and such objects, held by the child and the adult as support for movement. When the child is ready for further independence, ride-on toys can be used. They may have limitations: some may not withstand the weight of an older child looking for support; some may be heavier than necessary. Also, they should not cause social isolation (Pogrund *et al.*, 1992).

Blind children frequently lack the motivation to move in open space, and this is made worse by the fact that when they do move, they often bump into objects, fall over obstacles and may hurt themselves (Spencer *et al.*, 1989). For children who do not keep up with peers, who feel unsafe or hesitant in movement, or disoriented in the home environment, Orientation and Mobility (O&M) programmes are suggested. For this, the child's sensory skills, cognition, fine and gross-motor developments, receptive language and communication, self-help and socio-emotional development should be at the required optimum level (Pogrund *et al.*, 1992). Today it is recommended that a cane be introduced to a child as young as 2 years old, as the skill is a developmental one and can be corrected as the child grows.

DEVELOPMENT OF A SENSE OF SELF AND BODY IMAGE

Table 7.3.1.1. Step to Step Sequence Proposed for Body Image and Spatial Relationships
(Source: Cratty, 1964, cited in Pogrund *et al.*, 1992: 85)

1. Awareness of touch: movement by the whole body, with proprioceptive, kinaesthetic and tactile input.
2. Awareness of body parts through movement: by hand watching, clasping hands in midline, moving feet to mouth, etc., the infant understands how body parts are connected and thus can be aware of proximal space.
3. Identification of body parts:
    1. Identification of body planes: understanding body through perspectives of top to bottom, side to side and front to back.
    2. Understanding the relationship of body parts and body planes to movement (laterality and directionality), size, place, bilaterality, colaterality (pairing limbs), differentiation of halves of body.
    3. Identification of self in relation to objects and space.

Cratty (1964; cited in Pogrund *et al.*, 1992) suggests that a child cannot understand the external space affecting his/her movement until able to organise internal space (*Table 7.3.1.1.*). To be aware of the self in the surrounding physical world, the blind child will have to acquire the concept of distinction of self from the rest of the world, the concept of body image and ability to represent self in linguistic usage (Warren, 1994). Warren (1994) states that it is widely accepted that the blind infant has greater difficulty in establishing a body image than does the sighted infant. *Body image,* which is the mental picture that one has of one's body in space (Siegel & Murphy, 1970; cited in Warren, 1994), involves knowledge of the body parts and relationships among those parts; their utilisation individually and collectively for purposeful activity, and how they relate to one's spatial environment (Mills, 1970; cited in Warren, 1994).

Cratty and Sams (1968; cited in Spencer *et al.*, 1989) have devised a test to assess blind children's body image:

1. Body planes: the child has to identify front, back, sides, etc., of his/her own body, then place objects in relation to these planes.
2. Identification of body parts.
3. Body movement: of whole body and limb.
4. Laterality: the child indicates his/her own right and left, and places objects accordingly.
5. Directionality: the child identifies left and right sides of objects and of other people.

Hill and Blasch (1980; cited in Spencer *et al.*, 1989) add to the identification of body parts, the everyday function of each part. A research by Cratty and Sams (1968; cited in Warren, 1994) identified four phases of body image development:

2-5 years	- body planes, parts and movements
5-7 years	- left and right discrimination
6-8 years	- complex judgements of the body and body-object relationships
8+ years	- understanding of another's reference system.

Body image has been assessed by other constructive methods and formal scales as well: Miller (1975; cited in Warren, 1994) asked blind children to draw the body with raised line kit, and name the parts. Witkin *et al.* (1968; cited in Warren, 1994) asked them to construct a person from clay. Kephart *et al.* (1974; cited in Warren, 1994) asked for descriptive information. Results of these studies indicate that, as the blind child's experience of independent mobility increases with age, the body image improves.

COMMUNICATION, SELF-REPRESENTATION AND LANGUAGE DEVELOPMENT

One of the major difficulties that the blind infant and mother face, which in some cases can isolate the infant and cause deprivation of social contact, is the lack of a vocabulary of signs (Fraiberg, 1977). As visual discrimination leads to preferential smiling in the sighted infant, the mother of the blind baby is distressed in not having eye engagement, and not receiving a smile is often interpreted as no interest. The parents will have to learn to watch the well-being of their child through body language, which children instinctively know about, since, before using words this is the only language available to them (Quilliam, 1994). It should be noted that motor expression can be observed in the healthy, adequately stimulated blind baby (Fraiberg, 1977).

The most observable means of communication for the blind infant to demonstrate interest or emotions, will be through the use of hands (Fraiberg, 1977). Around 5-8 months, the infant's hands can be exploring parents' faces, tracing features for familiarity. By 4-8 months, parents can initiate dialogues, like babbling, vocalising, or imitating sounds and noises. Towards the end of the first year, he/she makes a directional reach towards sound, then expressions such as 'I want' or 'pick me up' through extended hands and arms can be observed (Fraiberg, 1977). In the second year the infant vocalises to initiate contact, and to make sure there are others around (Fraiberg, 1977). Intensive exploration of objects and environment may be a necessary precursor to verbal comprehension and language structure. Comparison of the first 50 word vocabulary of the blind and sighted infants by Anderson *et al.*, 1984; Bigelow, 1987; and Landau, 1983 (cited in Ferguson & Buultjens, 1995) show that blind children use more specific nominals, like names of things, due to limited experience in a social environment and using language mainly in an expressive style (Warren, 1994). That blind children at pre-school age are generally uninterested in listening to stories, is a clue to a different start of language, as well as to certain incapabilities in symbolic representation.

Some blind children may not achieve 'I' usage up to school years, or may refer to themselves as 3rd person as they begin using language. This indicates an impaired ego development; blindness may impose obstacles to the development of a self-image and the construction of a proper sense of self. They may not enjoy imaginary play, due to incapability of representation, and invention in play (Fraiberg, 1977). Recent studies by Rogers and Puchalski (1984b; cited in Warren, 1994) suggest that the ability to represent self symbolically in play as well as in other conceptual ways may exist among blind children of 18 to 37 months. The child will have achieved this when he/she represents him/herself in doll play, for this indicates that he/she has reconstituted him/herself as an object (Fraiberg, 1977).

PERCEPTUAL DEVELOPMENT

The delay in mobility, limited opportunity in experiencing and having no control on the surrounding space will lead to cognitive impairment and to problems in sensory processing (Lewis, 1992). This does not mean less intelligence, but a failure in integrating the different facts learnt, as each item of information is kept in a separate frame of reference. Perceptual development may also be delayed until the child will understand the different frames of reference: what the different senses offer, and how they relate to each other (Millar, 1994). Gathering and processing of sensory information, that is, attaining sensory integration, is the foundation of one's ability to deal effectively with the environment. It involves all the senses and emphasises the tactile, vestibular (balance) and proprioceptive (body position - kinaesthesia) systems (Pogrund *et al.*, 1992). For an infant, the tactile sensation is primary, and operational at birth. It begins with hand-to-mouth play and progresses to reaching away from the body, and includes not only effects from outside but also from inside, such as hunger, pain and sleep.

Infants are attracted by loud noises, bright lights and figural properties of form (Warren, 1994). As for blind infants, the auditory system is developed early, yet it does not provide integration of events (Warren, 1994). Most of the auditory information will be meaningless when it cannot be connected to a familiar object or concept, or will be overwhelming for the child and tuned out. Gradually attention comes under internal control, an important cognitive skill to be achieved (Warren, 1994), and the infant can select a stimulus, localise the source, discriminate the sound, recognise the source and understand the meaning.

The infant must learn to gain access to the sound flux as a pre-requisite to being active against the world. Millar (1994) suggested that infants' limbs could be connected to sound-making objects. Toys that make sound when touched could also be placed within the infants' reach. Nielsen (1979) suggests that as the coincidental movements of the child result in sound, the child will be interested in producing these movements voluntarily. Then, the following relationship of development will take place: **conscious movement ⇒ sound ⇒ reaching ⇒ impressions of touch**. Nielsen thus stresses the importance of the variety of objects available to the child.

When engaged in an activity, the blind child must also be aware of other sounds produced in the surroundings (Nielsen, 1979) to be able to gather information of the ongoing events, or any possibility of danger. Witkin *et al.* (1971, cited in Warren, 1984) suggest that blind children develop better auditory attentive abilities, including auditory localisation. Obstacle sense (*echolocation*), which uses echo to locate obstacles, is known to be present before adulthood due to having to pay attention to auditory cues.

UNDERSTANDING OBJECTS

Many things are simply too large, too small, too fragile or too abstract for the child to explore tactilely or audibly. Perception of objects and events for the blind child may not always be rapid or complete. Once the child's attention is drawn to an object, the child should be encouraged to scan and explore objects to feel their texture and features, and to imitate movements on how to use it. The child should be helped in building up concepts constituting a whole for large objects and familiarising with the function (Pogrund *et al.*, 1992). Tactile sense is an important means through which perceptual development is attained. Gaining information by touch helps the child in developing concepts such as amount, size, weight, shape, form, etc., which have to be achieved before beginning structured education in school. Using hands in this way helps also in developing fine-motor skills for tasks that will require use of finger movements and finger sensitivity.

Millar (1994) explains that different shapes require different complementary information from tactual acuity, active movement and spatial cues. The shape properties of an object may also require different types of exploratory activity for haptic perception, such as grasping, moving hands and fingers, keeping the hand stable during contact, large active arm and hand movements with body-centred reference, etc. The main measure of tactual acuity is the two-point threshold (Millar, 1994). The measure depends on how far apart two points on the skin must be before they can be felt as separate points when touched.

The perception of flat or outline shapes depending on a combination of tactile and finger joint stimulation, can be less accurate than recognition by active haptic exploration and being unvarying, will no longer be felt after a time (Millar, 1994). Acuity measured in terms of two-point thresholds is important in the perception of flat and continuous outline shapes placed on the skin (Millar, 1994).

Raised-outline configurations such as those used as symbols or characters in tactile maps and reading systems are systematically explored by active movements, usually with the forefinger of the preferred hand (Millar, 1994). Shape coding depends on using features internal to the form as references, provided that the contours contain one or more distinctive features. Very small shapes and very complex contours may be difficult to recognise and are avoided in tactile maps, to prevent clutter. This is also a reason that translating visual print letters, even capitals, into raised outlines has not been a very successful solution for reading by touch (Millar, 1994).

The Braille alphabet consists of very small raised-dot patterns; the presence or absence of any dot from the 2 x 3 matrix denotes a different character. Perception of each pattern typically depends on exploration by one finger (Millar, 1994). Loomis (1981, cited in Millar, 1994) demonstrated that for touch, dot patterns are easier to recognise than print letters. Braille requires a good amount of practice, and developed tactile acuity.

The recognition of vibrotactile patterns depends on passive but intermittent and successive stimulation of the skin (Millar, 1994). Systems of vibrating pin matrixes have been used in devices designed to substitute information to the skin for that supplied by vision. One such device, the Optacon[4] provides stimuli felt by the finger ball at the fingertip, which rests passively on the vibrating pins that convey dynamic impulses. Stimulus change is needed for perception by touch; without which the sensation would be lost (Millar, 1994). In terms of stimulus change, the information is similar to that which active movement by the finger over the same patterns would provide.

COGNITIVE DEVELOPMENT: THE EQUILIBRIUM OF BASIC CONCEPTS

As studied in the preceding sections, hands-on experience and verbal information, introduced playfully, is important for the pre-school blind child to learn through exploration, experiencing, imitation and, in time, inner representation, in terms of abstract thinking and development of the more complex concepts. Concepts such as amount, volume, weight, mass, classification and

[4] The Optacon is a reading device with a hand-held camera with a scanner for print. The patterns of print letters picked up by the scanner are translated into pulses delivered to the pad of the finger via the array of vibrators. The ball of the finger rests passively in a small (5 x 20, or 6 x 24) array of benders which can deliver vibrotactile stimulation at a frequency of 230 Hz. (Millar, 1994).

seriation are normally established between the ages of 6 and 11 for the sighted child, supported with experience and manipulation of the surrounding space (Lewis, 1992). Piaget also dwells on the acquisition of the concepts of *time*, *quantity*, *quality* and *spatial relations*. Nielsen (1990b) suggests that blind infants who achieve a relatively proper equilibrium of these concepts may more probably catch up with their sighted peers in cognitive development. Age at visual loss, intelligence, school and home environments and cultural variables all have their influences on the establishment of these concepts. Nielsen (1990b) explains this in relation to the blind infant as follows:

Experiences of Time

Within the first weeks of life, the sighted infant starts relating time to activity. He/she sucks for a short or a long time, with long or short intervals, looks at objects for different lengths of time, decides for how long to be stimulated. When the infant holds an object and then lets go, he/she will look for it, control its position and can regrasp it when he/she likes. The infant realises that there are sequences of darkness and light during a day. These are all temporal activities that the infant experiences in developing an understanding of *time*. The blind infant misses visual and auditory modalities as means for early temporal activities. At early stages, regular routine daily activities (sleeping, waking up, being dressed, being fed, being bathed and played with) and being talked through these activities, will therefore play an important role in giving the infant an idea of the temporal structure of life.

Quality

As Nielsen (1990b) points out, the notion of *quality* is closely related with an infant's experience with his body, objects and space. The more the infant is mobile and the more in contact with objects, the more he/she learns about their tactile qualities and how the perceived olfactory and auditory qualities relate to them. A major concern is to encourage the use of hands, in order to have contact with and explore objects and spatial features. Quality is not only the tactile sensation from contact with an object in the form of size, shape and texture. It also involves sensations like hot, cold, smooth, rough, easy to move and resistant, and can be felt from changes in temperature, airflow, etc.

Causality

Nielsen (1990b) explains that by repeating the same activity, the infant learns about connections between own actions, their effects on self, and on the surrounding world. The sighted infant visually controls the causes of happenings. The knowledge thus acquired enables transferring an ability gained from one activity to be used in another, and gradually achieving imagination. The child also remembers events, and what the objects or people can be used for. The lack of knowledge about causality negatively affects the blind child's ability to display interest in the surroundings and delays exploring activities, which in time would have helped to transfer ability, to remember events and to imagine.

Quantity

The sighted infant achieves the basis for understanding quantity through looking at several objects (Nielsen, 1990b). As the sighted infant is employing fingers in play, he/she is actually experimenting with quantity. The congenitally blind infant is passive with fingers, and seldom uses both hands simultaneously, missing the first accidental experience of dividing an object into two parts; thus missing the discovery that the parts are what previously was one item. If given parts of a construction set, he/she may not be able to play quantity games in the same way as sighted infants do and learn about few and many. Being unable to feed him/herself until a late age, he/she learns less about little and much. Walking late, or being more passive with the lower limbs, he/she cannot learn about quantity by kicking at the air or by taking steps.

Spatial Relations

Nielsen (1990b) argues that the first spatial experience the infant has is in the mother's womb, and after birth and in the cot, the infant continues to need the tactile sensations of contact to learn about spatial extent of environment. With less physical experience, there are delays in relating perceptual cues from objects and events within a spatial relationship to objects. The child's first knowledge about structures, shapes, weight and the stability and instability of objects are sparse or non-existent, and the child will have difficulty in going further in the development of spatial relations. The child has delays in learning that some objects make sound, some don't, some can be moved, some are stable, some are too large, some are small, and that they all have separate functions within their location.

DEVELOPMENT OF SPATIAL UNDERSTANDING AND SPATIAL BEHAVIOUR

Spatial Concepts

Warren (1994) remarks that, understanding the unknown physical world requires the achievement of object permanence, properties of matter, causality, time and a sense of spatial structure. Stages in the development of early spatial relations in congenitally blind children suggested by Nielsen (1992) can be explained as follows:

Stage 1. Accidental movement resulting in the burgeoning of awareness that there are objects out there somewhere.

Stage 2. Conscious pushing or touching of objects.

Stage 3. Grasping and letting go, soon followed by grasping and holding on to objects.

Stage 4. Immediate and deliberate repetition of an activity.

Stage 5. Tactile exploration and/or experimentation with the sound-making qualities of various objects, resulting in the kinaesthetic integration of the tactile and aural qualities of objects.

Stage 6. Comparison of objects; by this stage reaching for objects in specific directions and positions has become precise.

So for blind infants, the spatial world is primarily organised in relation to *self*. Even after infancy, for pre-school and school-age children, spatial representations are constructed on the basis of kinaesthetic and motor cues, such as distance from the body and the amount and direction of movement required rather than an external spatial strategy in spatial tasks (Millar, 1994). Yet as Millar points out, the ability to use an external strategy effectively increases with age. Pogrund *et al.* (1992) propose a sequence in which a child develops basic spatial concepts as follows:

1. Mapping of the immediate body
2. Mapping of proximal space
3. Mapping of distal space
4. Mapping of near-range object-to-object relations
5. Mapping of body-to-object relationships
6. Mapping of size and shape relationships
7. Mapping of part-to-whole relationships.

In summary, the child's understanding of the surrounding space will begin from own body, then progress onto *topological space*, *projective space* and *Euclidean space* (Piaget & Inhelder, 1997). *Topological* spatial relations are concerned with the properties of a single object or configuration, which the child does not yet locate within a global reference system. This reference system, together with the appreciation of changing points of view and the measurement of distances, becomes possible only as *projective* spatial concepts are constructed. With the development of the more advanced *Euclidean* spatial concepts in late childhood, the child can operate a reference system that is independent of any particular point of view, and which includes distance and time measurements in spatial judgements.

Spatial Perception

The human body is anatomically and physiologically constituted to receive gravitational and three-dimensional information through a number of convergent channels, centred both on external objects and on the body, and to code them by reference frames based on vertical and horizontal directions (Millar, 1994). Vision may not be a necessary basis for the development of this ability. This perceptual capacity normally emerges in infants, though more slowly in blind infants (Pick & Acredolo, 1983). Pick and Acredolo (1983) point out that visual experience plays an important role in the development of the perceptual process through which the person relates physical movements, to knowledge of the surrounding spatial layout, without the need of environmental reference information. Lee (1978; cited in Pick & Acredolo, 1983) suggests that the three types of information processed to understand the body in relation to space, are all provided by vision:

Exteroceptive information: Specifies the layout of surfaces in the environment and properties of objects and events.

Proprioceptive information: Specifies the positions and movements of body parts relative to other body parts, and orientation of the body with respect to earth, depending on kinaesthetic and equilibratory information.

Expproprioceptive information: Specifies the position facing direction and movement of the body as a whole relative to the environment.

With the loss of vision, what and where can be answered through the haptic-proprioceptive system of perception, by touching things for size, shape, surface texture and state of motion. It provides the same kind of information as vision, but not as efficiently, and in a much slower process, as it is limited and its examination of most objects and spaces is done serially. The serial perception of parts that results from serial examination must then be integrated to achieve the perception of whole objects and spaces (Foulke, 1982; cited in Potegal, 1982). Pick and Acredolo (1983) suggest that non-visual perception of locomotion (based on joint, muscle, and vestibular feedback) is expproprioceptive and perceived spatially in relation to the environment. Infants may not perceive their movements from place to place expproprioceptively, instead they may perceive them proprioceptively, as a sequence of limb movements or body positions, which are not spatially integrated (Pick & Acredolo, 1983). Alternative perceptual systems used by the blind traveller for locomotor guidance are the auditory system, the tactile-kinaesthetic system, and to a lesser extent the olfactory system (Spencer *et al.*, 1989).

ENVIRONMENTAL AWARENESS

The more toddlers have mobility experience, the more they have opportunities to discover that their own movements alter spatial relationships with respect to features fixed in the surrounding space. Pick and Acredolo (1983) explain that this development of spatial updating and expproprioception is based on neural maturation, experiences of independent locomotion, and although indirectly, on visual experience. With more experience, the child with no vision gains familiarity with the provided spatial information, and as Millar (1994) points out, learns to make use of all cues. Initial experiences in vision and hearing, distinguishing bright light from total darkness, correlation of own movements with other cues from external sources, and other feedback the child obtains from repeated trials, are involved in this process. Once the child is independently mobile, three types of information are crucial for getting around in the environment (Millar, 1994):

- Advance information about what lies ahead, to avoid obstacles.
- Information from as many fixed sources as possible in the external environment: to orient oneself in relation to a fixed location and to update cues for moving around the environment and getting to the destination.
- The relation between different reference frames, being able to relate different sensations caused by the same event, and learning to make use of different perceptual modalities in order to gain spatial information.

Orientation skills of using the remaining senses to establish one's position in the environment (Hill & Ponder, 1976; cited in Pogrund *et al.*, 1992) play an important role in introducing the child to a new environment. Being familiar with first the home and later the school environment, is important for the understanding of logical spatial connections. The child should have opportunities to systematically explore and as Pogrund *et al.* (1992) suggest, have them verbally described, as this will help with relationships of objects and places, combining landmarks with tactile, auditory and olfactory cues, thus constructing mental imagery that eases orientation in spatial tasks (Millar, 1994). At pre-school age, the blind child could be introduced to active street life, and routes to places of different activities such as shops, library, parents' workplaces, hospitals, etc. The child should receive explanations about the flow of traffic, route intersections, corners of an intersection, curbs, curves, ramps, stairs, etc.

All this information will help the child build the knowledge that there can be considerable predictability about the arrangements of objects on streets and intersections of streets (Spencer *et al.*, 1989). This regularity can assist in providing a predictable path, as well as the knowledge that objects that can be obstacles (fences, lampposts, litter bins, bus stops, etc.,) or sounds from the surrounding, also conform to regular patterns. If not helped to systematically learn about the physical area and its activities and sounds, an enormous amount of energy and valuable learning time in trying to sort these things out for themselves would be expended and perhaps a wrong impression may be gathered (Buultjens & Ferguson, 1994).

SOCIAL DEVELOPMENT

Self-stimulating behaviour

Not providing children with physical opportunities may make them turn to their own bodies and develop self-stimulating behaviour, to fill in the sensory void they experience (Pogrund *et al.*, 1992). Hypotheses as to its causes are: a need to increase level of sensory stimulation inadequate as a result of social deprivation, or for self-regulation in the face of over-stimulation. Knight (1972; cited in Warren, 1994) suggests stress or novelty in the environment, as causes. Nielsen (1990a) suggests it is a result of lack of opportunity to move on to the next stage of development. Tait (1972a) explains that it is natural for blind children to resort to self-stimulating behaviour to maintain a certain level of personal involvement, and suggests that an insecure mother-child relationship would shy away the child from the external world and turn him/her to the safe world of the body, rejecting all other potential sources of stimulation.

Brambring and Tröster (1992) divide such behaviour of a repetitive nature, also called stereotypical behaviour, into two categories: those that are frequent and long lasting such as poking, pressing, rubbing eyes and body rocking, and those that are infrequent and quickly disappearing such as making faces, sniffing, pulling or twisting hair, opening and closing lids and doors, and wiping movements. Boredom, delight, being read to, excitation, anger, being left alone may bring on such behaviour, which may inhibit social interactions, interfere with the child's attention to events, or result in physical injury (Warren, 1994). On the other hand, it is suggested that it may be an outlet for the energy not used otherwise.

McHugh and Pyfer (1999) explain that rocking, a common stereotypical behaviour, may emerge early in life and be difficult to control. Blind children tend to rock particularly while engaged in routine tasks and activities. Yet, this may affect very little or not at all, the performance of functional tasks. McHugh and Pyfer (1999) also explain that sensory deprivation experienced by blind children may increase the need for movement and suggest plenty of motor experience and physical play. As children grow older and their motor skills develop, they are able to integrate such repetitive behaviour into functionally more complex and socially acceptable patterns of movement, helped on by being provided with meaningful activity.

Social adjustment

As language develops and meaning is attributed to words, the child will probably understand that others have the ability to do things he/she cannot (Pogrund *et al.*, 1992). With the development of language, tonalities of happiness or anger in voices become important to the child. As facial impressions are not observed, he/she may find it hard to understand that feelings do change after a time. In stressful situations, instead of self-expressive response, tantrums or helpless behaviour may be observed, or the child may become unnecessarily complying to prevent confrontations. The child must be taught how to discharge anger, as suppressed anger causes withdrawal, anxiety and fears (Pogrund *et al.*, 1992), and can be energising if used properly. Another characteristic problem for younger blind children is the ease with which they may slip into fantasy, and face the difficulty of differentiation of make-believe from reality, which should be overcome by the age of 6.

Blind children are less likely to initiate social contacts. Their frequent help-seeking behaviour is generally for gaining attention (Imamura, 1965; cited in Warren, 1994). They also may be less likely to show positive indices such as smiling or sharing things. They tend to orient behaviour according to the help of the teacher or another adult. During school, stereotyped behaviours can also be a factor in setting blind children apart from their classmates; other factors include differences in physical appearance, use of technology and materials, the need for assistance, physical separation, educational modifications, unusual behaviour and atypical social interaction skills (McHugh & Pyfer, 1999). These children should be encouraged to initiate actions with peers, to maintain relationships and to resolve conflicts in a non-aggressive way. Very basic social skills for blind children are to learn to face others during conversation, to keep their hands to themselves in a first encounter, and to eliminate stereotyped behaviour. Also having good hygiene and age-appropriate dressing are positive aspects in socialisation (Pogrund *et al.*, 1992). Sighted children may not always be willing to show friendliness and may tease, which seems to affect partially sighted children even more deeply (Warren, 1994). Rather than overprotecting, the child should be encouraged to take responsibility. Performing well in a task will increase self-esteem and in turn will positively affect the perception and opinion that others have of the child.

7.3.2. RESEARCH TOPIC II: PLAY BEHAVIOUR OF BLIND AND VISUALLY IMPAIRED CHILDREN

Recognition of the importance of play in children's development has led to studies of the impact of disabilities on children's play. Although playing naturally occurs in all young children, most special needs children have to be taught about toys and how to play. This is the case for blind and visually impaired children as well. As studied in *Research Topic I*, blindness, especially in the early years of life, may severely restrict experiencing the world, which will reduce the potential for physical, cognitive and social learning in blind infants and pre-schoolers; and will be reflected in developmental delays in play behaviour (Tröster & Brambring, 1994).

GROSS-MOTOR PLAY PROVIDING BODILY STIMULATION

As studied in *Research Topic I*, and stressed by O'Donnell and Livingston (1991), limited or no vision results in abnormal posture, and limited understanding of body and space, affecting performance in functional play skills. Terry and Shaffner (1972) describe the poor motor conditions blind pre-schoolers can be in, such as difficulty in tolerating being in a sitting position (*Figure 7.3.2.1.*). Blind children, through playful exercises may be taught how to hold body and may benefit from being in different mediums for different sensations. Ross and Tobin (1997) suggest the medium of water where the child can float by means of gross-motor activity, hearing the reaction of water to limb movements as splashes on the water surface, while in close contact with the adult. The ball pool is another popular environment where children are in tactile contact with light balls (*Figure 7.3.2.2.*).

Figure 7.3.2.1. Totally blind infant at lunch
This child cannot sit upright even when he is eating. His teachers believe this is due to limited physical experiences he has had as a baby in the cot.

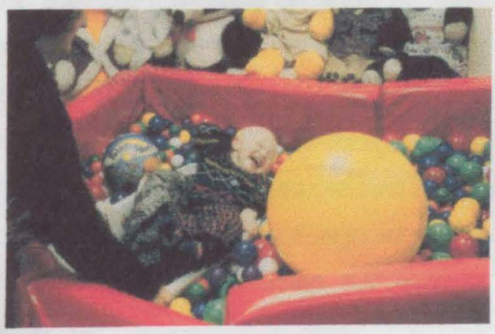


Figure 7.3.2.2. Totally blind infant in the ball pool.

In centres for visually impaired children, there may be found sensory environments providing various bodily stimuli like vibration, sound, different tactile sensations, such as feeling the wind blow, and handling sand and sticky or wet materials and also equipped with lighting of different effects to stimulate the remaining vision of the child.

GRADUATION INTO MORE COMPLEX MODES OF PLAY

Tröster and Brambring's (1994) study shows that blind children:

- explore their surroundings and the objects in their surroundings less often;
- at the ages of infancy and pre-school, frequently engage in solitary play that is repetitive and stereotyped;
- exhibit spontaneous play far less than sighted children;
- do not or only rarely imitate the routine activities of their caregivers;
- play less frequently with stuffed animals and dolls and rarely engage in animism;

- play less frequently with peers and usually direct their play towards adults;
- exhibit clear delays in the development of symbolic play and role play; and
- engage in play that contains fewer aggressive elements.

The play experiences of a visually impaired child may be impeded by the child's fear of moving around play areas and also by overprotective parents. The child may also be limited by delays in spatial concepts and orientation, fine-motor skills, self-help, problem solving, and organisational skills. Such children may have the cognitive ability to develop play schemes, but may be hampered in carrying out the schemes by substantial delays or deficits in the mentioned areas (Skellenger & Hill, 1994). Blind children's impaired access to play materials and their manual and co-ordinative difficulties in dealing with material objects will require extra time and help, to discover what and where their toys are and what to do with them.

Skellenger *et al.*'s study (1997) indicates that the blind children observed during a play session, spent a lot of time in behaviours other than play such as preservation, simple manipulation, exploration, transition and non-involvement, and when they did play, they engaged primarily in functional-relational and gross-motor play rather than *pretend play*. On the other hand, it is particularly important for young blind children to try out through the safe medium of pretend play, what they might find difficult or impossible to experience in real life (Ferguson & Buultjens, 1995), as long as they distinguish make-believe from reality. Warren (1984) discusses the idea that blind and visually impaired children are less imaginative and creative than are sighted children. Although they can be encouraged to play with support from adults, when the support is withdrawn, they may fall back to simple patterns of behaviour.

Tait (1972b) explains the reason why blind and visually impaired children tend to be more engaged in *manipulative play* as: having tactile pleasure from handling play materials, a need for examining closely the objects familiar to sighted children, or, using the play material as a device to continue contact with the adult. Exploratory play can be described as examination of an object to find out about it and remove uncertainty, with further examination to discover new features missed, and how to make use of it as a plaything. Buultjens and Ferguson (1994) explain that blind children may display *repetitive play* with objects, which should be overcome at a certain stage of development. However, *repetitive play* is an important stage in the development of motor control and the understanding of relationships of objects. It is important, though, to distinguish it from *stereotyped behaviour* to help the child continue with more meaningful play such as *exploratory* and *creative/constructive play*, which involves the child in interaction with objects and the environment.

PLAY INTERVENTION AND TECHNIQUES FOR TEACHING BLIND AND VISUALLY IMPAIRED CHILDREN TO PLAY

Children with visual impairments may need specific intervention in how to play with toys or with peers. Interventions in their play media would have to be based on specific developmental data, not on standard data on sighted children, as blind children's acquisition of individual types of play behaviour takes a different course. A primary step would be to assess the level of vision[5] that the infant can use, and then to facilitate object interaction through improving environmental conditions accordingly. Then children can be taught to interact with objects, to receive stimuli, and in time are encouraged into playful behaviour. Each stage of play that the child displays is important in its own right and should not be accelerated but enriched at that level. Intervention, therefore, may be more beneficial to blind children if it is in the form of encouraging exploration, naming of objects in the environment and assisting the child in using strategies more efficiently (Ferguson & Buultjens, 1995).

It is important to provide children with playthings and activities that are chronologically age-appropriate (Rettig, 1994). Some children will need little help to start play; others may hardly play at all, being easily distracted and inattentive, discouraged and destructive, flitting from thing to thing, or being very obsessive in their play (Riddick, 1982). For children who like playing with adults, and who cannot play alone with toys, or are uninterested in people, toys can be introduced as part of a social game like those in which participants have to take turns. Children who ignore toys or are destructive should not be given the toys they find difficult or frustrating when playing alone. Their attention can be captured through toys that produce interesting effects such as sound, movement, light, etc. Apart from physical and functional aspects of objects, toys and playthings that encourage the development of symbolic representation, language and socio-emotional development, and help increase the child's sense of self, should be selected.

The environmental setting may require adaptations or modifications for the children's spatial awareness to increase. Blind children require an emotional security base to develop effective exploratory behaviour. It is essential that adults provide a safe and supportive atmosphere for play. Removing distracting materials and keeping the play area clear will help the children in concentrating on the activity. It is also important to find the most suitable time, such as when the child is relatively more quiet and attentive, or when other children are away (Riddick, 1982).

Of particular importance is the need for the adult to follow the child's lead to participate as a play partner and to know when to resign from the play setting to avoid intrusive, dominant and constant adult presence (Ferguson & Buultjens, 1995). Communication between the adult and child will affect the child's interest in the activity. In certain cases communication may mean

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[5] In order to assess residual vision in the partially sighted child Riddick (1982: 148) has developed a set of questions:
'If the child is laid down does he/she turn his head to a light source?
Does he/she seem to see best in very bright or rather dim conditions?
At what distance is he/she most likely to reach and grasp a toy at?
Does he/she follow people round the room with the eyes even if they are not speaking or vibrating the floor?
At what distance can he/she follow a moving or dangling object with the eyes and what sort of size does it have to be?
Does he/she seem to see most objects within a reasonable distance or only those that are very bright or shiny?
Do objects have to be placed in a specific part of the normal field of vision before he/she notices them, above or below eye level, to the left or right?
Does he/she seem to see large objects but not be able to pick out small ones?'

waiting for a specific response or reaction from the child after an approach on the adult's side (Riddick, 1982). Often a child's concentration during a period of activity is broken by an adult saying 'well done' or 'good boy' at the wrong moment; or a child's need to process new experiences mentally, is interpreted during a period of rest by prompts of 'do it again'. Therefore timing of adult intervention is important and must be kept to a minimum (Dunnett, 1997).

Learning to play may be a difficult process for the child, who might be overwhelmed by the stimuli. This may lead to periods of inactivity during play sessions, followed by periods of activity, which Nielsen (1990a) believes is part of the learning process. The child may not play with a novel toy in the way the adult might expect, yet it will still be of use if it is played with at all. Nielsen (1992) stresses the importance of children learning by themselves, the role of the adult being to provide the appropriate environment and materials and to enable the child to focus on important aspects of the environment through verbal and other prompting.

Techniques employed in teaching a child a task, an activity or a way to solve problems, may also be used in teaching to play, as play may be a task to carry out, for the child. One method is *task analysis*, where a strategic approach is used by breaking down tasks into smaller steps that can be overcome one at a time. Another method *is backward chaining*, where the adult carries out the task for the child and the last step is left to be concluded by the child. The *modelling* method encourages the child to carry out the imitation of a technique used by an adult simultaneously. *Motoring* is the technique of physical prompting where the adult guides the child through the activity, hand-over-hand. *Demonstration* is teaching a task by showing how to do it while the child observes. Finally *reinforcement*, such as a reward, could be used with all these methods to provide positive encouragement. To summarise, the adult plays a central role in teaching blind children to play. The role must be played with utmost sensitivity to maintain the precarious balance of communication between adult and child and between child and environment.

FUNCTIONAL PLAY: DISCOVERING AND ACTING UPON OBJECTS

Having numerous play material around does not necessarily improve the child's ability to explore and manipulate them. Dote-Kwan and Hughes (1994) explain that this may in fact bombard the child and shorten the period of interest, thus preventing the child from engaging in higher levels of play behaviour with any particular toy. Alternatively, a child may choose the same three or four toys for most of the time in play sessions and repeat the same simple play themes with only slight variations, thus minimising field of interest (Skellenger & Hill, 1994).

Young children with severe learning difficulties, as well as blind children, are often tactile resistant or tend to throw any object given; and will need lots of hands-on experience before they are ready to hold objects (Dunnett, 1997). Nielsen's Little Room (*Figure 7.3.2.3.*) is a small environment designed to give an idea of object permanence to blind children who have not yet developed a sense of 'self' and 'objects out there' (1979, 1990a, 1990b, 1991, 1992). This shelter (W: 600 mm, H: 600 mm, L: 900 mm), enclosed with a clear plastic roof, eliminates sound from outside. The child is on a resonance board, a wooden platform raised 2-3 cm above the floor. Any movement that the child makes on this board produces sounds that echo and provide accentuated sensory feedback (Dunnett, 1997). Objects of different tactile, auditory and olfactory qualities hang around the roof and from the walls. The child makes accidental contacts with them, and senses them. With more experience, the child understands that although he/she ceases contact with these objects they are still there and can be found. In time, the accidental gestures give way to a more conscious handling of these objects.

Figure 7.3.2.3. The Little Room with the resonance board.

To introduce the young child to exploration, Fraiberg (1977) suggests that the infant is seated at a table surface surrounding at three sides, to explore the surface, find objects and become familiar with them. The next step will be the use of a playpen, a relatively restricted space which the child will come to know and feel secure in. The playpen is a defined area for exploration, and a toy cast away is found again in it.

Some children may like lying flat on the floor, with their body parts on different textures. Once out of the playpen, the child can be placed on different textures, rugs, furniture, grass, etc. Feely boards of different materials and textures and feely bags filled with sand, peas, etc., can be prepared to put around the child (*Figure 7.3.2.4.*). Some children may like fur and wool, but some will dislike the sensation they provoke and instead enjoy smooth surfaces such as metal and plastic. Even if the child is not handling things, he/she may frequently be fingering or scratching at surrounding textures (Riddick, 1982). One major consideration would be to provide a safe medium or to secure features that may carry a potential for danger[6].

[6] Safety Considerations for Blind and Visually Impaired Children (Pogrund, Fazzi & Lampert, 1992: 97-100):
Pillows and stuffed animals should not be given to small infants in case they smother themselves
Objects handed to them must be large enough not to swallow
Larger objects should not have small detachable parts
Infants should not be left unattended in walkers, swings, etc.
Safety straps should be used on changing table and high chairs
Electrical socket plugs should be covered
Head, knee and chin level obstacles should be watched out
Corner and edge protectors should be used
Stairs and dropoffs should be secured with safety gates
Cords and wires should be secured with shorteners and rubber housings
Furniture changes must be introduced to the child and it should be ensured he/she understands new arrangements
Throw rugs and such obstacles should be secured
Tablecloths should not hang over in case children pull and spill hot food or knock down candles
Colour and contrast should be used to provide ease for children with residual vision in detecting areas of certain functions and oncoming obstacles
Plastic and rubber under mats should be used to stabilise objects in front of the child
Out door play yards should be fenced
Surface changes (grass-gravel, cement-dirt, carpet-linoleum) should be provided to define walkways and activity areas.

Skellenger and Hill (1994) explain that once used to handling toys, when playing alone, blind children prefer toys and materials that have a distinctive tactile or auditory effect. A typical play behaviour during solitary play is the tactile exploration of the articles of daily living and surroundings, and are interested in producing noises. The blind child's primary toys with interesting sounds or textures can be rattles, suction rattles attached to the child, sound-producing balls, activity centres and music boxes. Play materials that allow having manual control over the cause-and-effect of actions and motivate by the tactile or auditory effect, will stimulate the blind child to play with objects (Tröster & Brambring, 1994).

Figure 7.3.2.4. A feely dog prepared by nursery teachers for visually impaired children.

Sound-making and musical toys may be very useful in teaching the child to relate between actions and resulting reactions from the object. These toys may help the child to use hands for banging, pulling, hitting, pressing, waving, etc., but may produce high levels of repetitive, self-stimulating behaviour in less mature blind children. Objects producing loud, squeaky noises should be introduced with caution though, as they may be alarming. Older children will enjoy radios and tape players, though these may also invoke passive behaviour.

Parsons (1986a, 1986b) suggests that specially designed enriching environments where numerous interesting and stimulating toys and objects requiring active involvement are, is an important basis in expanding the play behaviour repertoire of the blind child. Schneekloth (1989) suggests that continually available and non-evaluative play environments should be provided in which are found play props that provide constant feedback and include props for motor play such as climbing, swinging, sliding etc., as well as toys requiring less effort such as exploratory play on a smaller scale. She suggests that such play environments should be scaled to children to allow them to determine how built environments are constituted so as to understand how the floor, walls and ceiling are joined together defining a three-dimensional spatial volume. Schneekloth also points out the importance of providing complexity (of the features, details or activities offered by the equipment), to provide maximum opportunities of exploration.

SYMBOLIC PLAY: ENCOURAGING IMAGINATION AND REPRESENTATION

Froebel (1826; cited in Ferguson & Buultjens, 1995) saw thought and language as developing through intensive play with objects found in the environment. The more objects a child experiences, the greater number of connections will be made and hence more complex ideas will be developed. Constructivists focus on the relationship between early play experience and concept development in infants and young children. Intellectual development during the sensori-motor period, the first two years of life, emerges directly from the infants' understanding of the world on what Piaget (1962; cited in Recchia, 1997) calls their *plane of action*. Concrete activities within their day-to-day experience precede and make possible the infants' use of intellect, thus forming the foundation for later mental development. What begins simply as sequences of sensori-motor activity, gradually develops into internal representations and affects the infant's mental development and intellectual capacity (Recchia, 1997).

In the second year of life, symbolic, fantasy, pretend, dramatic or imaginative play evolves in association with the development of language, representational thought and creativity (Piaget, 1977). The failure to play either imaginatively or socially may adversely affect language development, social adaptation and cognitive functioning. Social play, imaginative play and role play are generally late, but important to achieve. Such play may be best encouraged for blind pre-schoolers with real objects, such as tins, apples, and jars for shopping games, rather than models (Riddick, 1982). Miniature versions of everyday objects will not mean much to a totally blind child as they will not convey the same experience the child would have handling the real ones (Millar, 1994), and many toys will not be sufficiently representative of the ideas of reality they have (Lewis, 1992). It is likely that neither will traditional symbolic toys, like automobiles and dolls, represent realistic, scaled-down versions of real objects or persons in tactile or auditory terms. But as blind children approach conceptual reasoning, materials such as tea sets, grocery items and dolls will elicit more imaginary play (Rogow, 1981; cited in Langley, 1985). For symbolic play, it may be possible to develop toys that have a tactile, auditory or even olfactory similarity to real objects or persons. One way to facilitate blind children to grasp symbolisation may be to make the movement of the play action in reality rather than the features of the play object similar, such as the motion of the swing experienced by the finger touching a swing model (Tröster & Brambring, 1994).

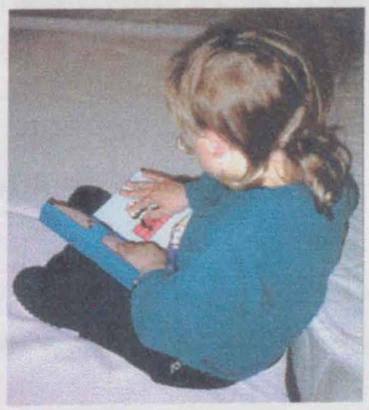

Figure 7.3.2.5. Partially sighted child reading and feeling Humpty Dumpty from a book.

Most mature blind children enjoy games with music and storytelling which are encouraging to the use of imagination and the development of a sense of representation. However, they may quickly drop into uninterest and stereotyped behaviour from lack of visual clues as to who is speaking or who is being spoken to, making them feel anxious or unsure (Ferguson & Buultjens, 1995). Story-time can be made more meaningful if the blind child is sitting near to the person telling the story and is given feely books, toys or objects which represent the characters or actions, to hold or explore while listening. Brambring (1993; cited in Buultjens & Ferguson, 1994) suggests that a young blind child taking well-known objects one after the other out of a box is indulging in the same activity as a sighted child leafing through a picture book. There also can be found touchy-feely books and story tapes for both totally blind and partially sighted children (*Figure 7.3.2.6.*).

SOCIAL IMPLICATIONS OF THE PLAY BEHAVIOUR OF BLIND AND VISUALLY IMPAIRED CHILDREN

It has been observed that children with visual impairments may be rejected or reject the company of peers in play settings (Skellenger *et al.*, 1997). Sighted children may find it difficult to adjust to the ability levels of blind children, and blind children may not be able to cope with the demands of play with sighted children. The quick and often unpredictable movements of sighted children may disorient a child with low vision, slowing the respond. Transitions may also be difficult, as they may resist moving from the known to the unknown (Recchia, 1997). These may be threats to their development of social skills as playing with peers is considered to be essential in this matter (Sutton-Smith, 1976; cited in Tröster & Brambring, 1994).

Children with visual impairment often choose to play alone or to interact with adults, probably due to their need to obtain information about the environment (Skellenger *et al.*, 1997) or in order to engage their lasting attention. Tait (1972b) notes that the blind children (4-9 years) she observed asked more questions than did the sighted children, towards furthering understanding of the environment, gaining information or assurance before attempting an action. This was also a way of maintaining open lines of communication with the adults. The adult caregiver becomes the mediator between any novelty introduced, and the child (Wills, 1968). With enhanced play with a supportive adult, the child can be physically modelled through daily activities and thus given the opportunity for repeated practice and refinement, before having to deal with real-life problems (Skellenger & Hill, 1994).

7.3.3. RESEARCH TOPIC III: CONTACT WITH BLIND AND VISUALLY IMPAIRED CHILDREN THROUGH VISITS

Apart from the literature review, to better understand the play behaviour of young children with blindness/visual impairments, numerous visits have been made to their educational and home environments to observe:

- how blind/visually impaired children of pre-school age play with toys or interact with objects in their nursery environment;
- how they play with toys or interact with objects in the home environment;
- what sort of play material they are attracted to or are interested in; and
- what the role of the teacher or adult is, within this interaction.

F. (3 y, 6 m) *Only child of single parent*

Date of Visit: *November 1998* ***Place:*** *Birmingham*

F. was born with visual impairment, and lost his residual vision during treatment. He has been diagnosed as autistic. He did respond to some sentences addressed at him, and could surprise by making comments on ongoing events. In general, he was by himself, rocking, spinning and speaking in a throaty voice. He was from time to time placed in a walker to stop him from spinning and falling on smaller children. F. did demonstrate some signs of ego development; he was silent when he heard his name called, approached and laughed, and bent his head to the floor. The teachers explained that he could be co-operative when in a good mood. F. during those days had a favourite object/toy he was obsessive about. This teether-rattle with three pieces on a plastic ring was always in his hands, and trying to remove it resulted in tantrums. In an environment new to him (like the next room), he used this object holding with both hands, in the direction of the movement, as a bumper, and also for his first contacts with novel objects he encountered on his way. Otherwise F. was not interested in the objects surrounding him, not even in toys that made noise, flashed light or moved. He sometimes seeked refuge by the table, the borders of which were covered with soft toys, touching these soft toys with bare fore arms, elbows and upper arms, or leaning his forehead on them when tired (*Figure 7.3.3.1.*).

Figure 7.3.3.1. F. resting by the table.

J. (2 y 6 m) *J. is the eldest of two children.*

Date of Visit: *November 1998* ***Place:*** *Birmingham*

J. could be considered a one-year-old infant at the time of the visit, both in bodily and in cognitive and emotional development. He was kept in bed by his mother, and was not spoken to, or played with and stimulated in any way until he was 1,5 years old and visited by council staff. J. could not sit straight by himself, and when left alone he remained in a lying position, his back or tummy in contact with the mattress. He had recently pulled himself up to sitting position, and also made a few crawls. He could reach out to objects, pick them up, and recognise them by their sound and touch. These progresses showed that it was still early to decide whether he had learning difficulties. J. was born with the last three fingers on both hands attached and had missing bones on his feet. He had recently had an operation to separate his fingers, which had tremendously improved his use of hands. When his hands were at rest, they demonstrated the typical grasping and ungrasping motion and flickering of fingers. He could not yet eat by himself.

When he heard a familiar sound or felt a familiar touch, he reached out, grasped and pulled the object to himself. J. was delighted to hear the crumpling sound of silver plastic sheets and to watch the flickering of light reflected on them. He also enjoyed being in the light room where he could watch the bubble tube or optical fibers. To do this, he leaned his head on the paper or tube, as he could not sit straight by himself. J. also enjoyed bodily sensations. He was delighted to be in the ball pool, and having the balls gently thrown over his body until he started to panic when they were up to his face. J. also liked a large bucket over his head and the bucket being tapped. He joined in with laughter to the echoing of the taps. In general, J. was a very friendly child who enjoyed the company of others. He is from a crowded family and since he had had a baby brother, he has shown progress in emotional development.

***D. (2 y)** D. is the older of two children.*

***Date of Visit:** November 1998* ***Place:** Bolton*

D. was an active, friendly child. He has relatively good residual vision. D. was delighted to play in the light room, and was very curious about a box full of different small objects and parts of old toys to explore. In interaction with his mother, D. was able to choose the objects she asked from him, using his hands and residual vision, and to name them.

***C. (12 y) and N. (8 y)** C. and N. are sisters who suffer from the same genetic condition leaving them totally blind and physically underdeveloped.*

***Date of Visit:** May 1999* ***Place:** Ipswich*

The two sisters are very small due to brittle bone disease, which prevents them from walking. Their overprotective parents have kept them away from physical activities or carrying out a task and completing it, though the girls are physically able to do some manual tasks. They do not have learning difficulties. C. was having her Moon reading lesson assisted by her teacher to recognise letters, and to read simple words of three letters. This was not easy as she was not co-operative and not enjoying the task; she could not pay attention for long. She could or would not bend forward to reach for the tabletop, and was not willing to use her hands and fingers to explore. She tended to use headache as an excuse to end the tasks asked of her. Nevertheless, C. was a sociable child, and preferred engaging her teacher in conversation to interrupt the lesson. She made verbal jokes and told funny stories she had learnt over the weekend.

N., the younger sister, not as much protected by her father, was also having her Moon reading lesson and was eager to learn. N. was the happier child and she displayed this by laughing, though laughter did not show on her facial expressions. She asked to listen to song tapes, joined in with the singing and moved her body to the music. N. also had a book tape played, through which she felt the accompanying feely book, written and designed by her teacher. N. had difficulty in holding the book open, due to the binding, which could have been solved by the use of a ring binder. Following, N. had her basic maths lesson where from a box she felt for identical objects and sorted them out in groups. Finally N. played with the Jody Pegs (*Figure 7.3.3.2.*) also designed by her teacher, where she had to use her pincer grip and wrist to pick, place, and sort the pegs. Compared to C., she made more use of her hands, but still had poor wrist control and strength. N. had to be reminded to search for and count three dots on a surface of 3x3 cm (*Figure 7.3.3.2.*), as she stopped exploring when she came across only one. N. was willing to be more bodily active but could not, due to the arrangement of the wheelchair, tabletop and displaying of objects. This factor can be controlled by using adaptable trays

Figure 7.3.3.2. Jody Pegs by J. Dunnett-Roberts.
The previous and the further developed versions.
The dice in the second picture is the one on which N. was counting the dots.

placeable at angles.

V. (5 y)

Date of Visit: *May 1999* ***Place:*** *Sevenoaks*

V. was a happy child who showed fast progress in learning and social skills. V. is totally blind, but has no additional disabilities. She is mobile, and made good use of her hands. During the visit V. was in a classroom situation, together with her peers. The day at school began with classroom activities where all children were given small tasks to complete at their desks. Following, they were read stories. After a break of snacks, the children had their indoor gym hour where they were free to play with the available props, such as balls, activity toys, musical instruments, etc. Then a structured session in the gym followed, where all children were partnered with an adult in doing physical activities, and singing the songs accompanying their movements. The next session was arts and crafts. In a separate classroom, the children were helped into their aprons, and at their worktops two teachers assisted them in making a sailing boat from paper rolls, plastic containers and paper. The children then made water colour prints of boats with sponge, in different colours. In the arts and crafts lesson, the primary concern was to make use of the arms, hands and fingers, to make the child concentrate on an activity, to get the hands used to 'mucky' activities, and to teach co-operation and turn taking (in the use of materials with friends and in contributing in the completion of the boat with the assistants). Every week, the children learn about a theme, and that week it was the sea and sea crafts. One of the children resisted strongly the teacher putting an apron around her, and verbally refused wearing it. The same child did not want to get involved with sticky wet paint, and hid her hands away from the worktop. V. was a co-operative child, and eager to learn and do things. When excited, as she was when talking to her teachers, V. tended to sway her head to the two sides, but remembered to stop in short. She had good interaction and communication with her friends, and recognised everyone in the room by their voices and the noise they made, such as footsteps, and the way they hit a toy or played an instrument.

M. (5 y)

Date of Visit: *May 1999* ***Place:*** *Sevenoaks*

M. who was in the same playgroup with V., is severely visually impaired, has learning difficulties, and signs of autism. M. expressed his preference to be left alone with facial expressions and gestures. He would respond to contacts from peers in tantrums and anger, or become introvert depending on his mood. He preferred to engage himself in repetitive play, by playing keys of musical instruments over and over again. M. also played with a toy with mirrors reflecting light. He used an electronic keyboard, and knew he had to switch it on before beginning. With the warning of the teachers, he stopped and switched it off, pretended to leave but stayed around. Believing the teachers were no longer interested in him, he cautiously switched the keyboard on again and continued playing. When he was taken away from the area, he burst into a tantrum, but ended it in a while when placed in an area where he felt secure. This was behind a big table facing the corner; under which were placed boxes filtering off sounds from the rest of the room.

He remained there in silence and clearly showed signs of protest and being offended, with his facial expressions. After a time he crawled out of the corner to join the others.

***L. (3 y)** is in foster care with a family with 2 teenage children, and sees his real mother regularly.*
***Date of Visits:** November 1999 and December 1999* ***Place:** Gillingham*

L. had not begun nursery yet, and his foster mother was bringing him to the playgroup sessions held once a month at a toy library in Gillingham, where specialist teachers supervise the play sessions and give advice to parents of visually impaired children on toys and play activities. L. has residual vision, he is physically fit, and very active. He was very dominant at the playgroup and required loud, big, hard toys. He tended to throw things. This was worrying his foster mother and the teachers, as an obstacle for L. to join in social activities with other children. Instead of restricting this behaviour, he was allowed to throw balls during a limited time of his play session to release his energy.

During a second visit at his home, L. was actively playing in an area devoted to him. He was familiar with the layout of the home. He was very interested in the washing machine and played with the lid when his foster mother was not looking. He was also a musical child; he enjoyed listening to music, and danced to the rhythm. He was very playful and although he had no verbal communication, he knew he could make jokes and make others laugh or cross, by responding with facial expressions or bodily gestures. He also could point at his body parts, including elbows and eyebrows. His foster mother explained he had some problems with his throat from birth, making it difficult for him to swallow, and to speak. L. had a wide selection of toys at home, mostly cars and balls, made of hard plastic. He had a teddy bear, which he never touched. His parents were trying to make him handle softer plastic toys, hoping in time he would get used to handling soft and fabric toys, which now he refused to do in tantrums, and even did not sleep with a pillow.

CONCLUSORY REMARKS ON THE DEVELOPMENT AND PLAY BEHAVIOUR OF BLIND/VISUALLY IMPAIRED CHILDREN TOWARDS PROBLEM SPECIFICATION

Information and knowledge gathered from both the literature review on the development and play behaviour of visually impaired children, and personal contact, have revealed certain issues in relevance to the design task in hand.

1. Expecting to arrive at a generalised model of (physical and cognitive) developmental behaviour of blind/visually impaired children in their play setting may not be possible, as each child displays an individual demeanour, related to additional physical or cognitive disabilities that the child may have, or the resultant behavioural problems the child displays.

- Individual behavioural differences may also be related to the specific abilities the children may have developed to compensate for certain aspects of their handicap.
- The amount of experience in the home environment the child has had prior to coming into the classroom setting, is another factor why each child is an individual case.

- Still another factor may be the teacher's or adult's contribution to the child's interaction with the world. The ways in which the teacher/adult approaches the child and introduces toys towards new concepts, encourages and emotionally supports the child, may create individual differences in further autonomous activities the child may wish to be engaged in.

2. As the children have experienced limited play behaviour, they display delays in developing a sense of self; have problems in mobility and thus acquire limited spatial experience, and refrain from carrying out activities on their own. These are important problems to address.

3. A common trait derived from both the literature review and personal contact is that, blind/visually impaired children are seldom willing to play, unless prompted.

- They seldom engage with the play material or toys placed around them on their own accord, preferring to recoil and rest inactive, displaying refusal to acknowledge communication with and awareness of their environment.
- Or else they have a favourite play material or object which they hold on to obsessively, or use repeatedly, displaying signs of stereotypical behaviour towards self-stimulation, or self-protection and emotional comfort, rather than play with aim (such as discovering objects and their properties, or using the objects towards a constructive act), thus interacting with and acknowledging the environment.

4. The children are not willing to play with their peers. They do join in classroom activities, carrying out parallel play behaviour, but not co-operatively. The occasional attempt at interaction of the more extravert children (those with milder visual impairments, or those older in age) was to make verbal comments to peers across the room, which in general received no response. This sort of attempt displays the wish to play socially, and means should be searched for, to provide this opportunity among pre-school children with blindness and visual impairment.

5. Even though many toys found in the market are available to the children and placed in their close proximity, these are seldom used unless prompted by the teachers, particularly in the case of severely visually impaired children with additional disabilities. This may be to some degree related to the nature of the available toys. The play value offered by the toys available in the market may not always be compatible with the nature of the play behaviour that results from the disabilities the children have. This stresses the importance of reviewing the toy market as to trend, technology, material and play activity, and to investigate what further may be offered. The review will also be useful to understand how children with and without sensory impairments may be brought together in a play setting, which is a means of integrating the blind child to future real-life situations.

To conclude, the issues discussed here point to the fact that visually impaired children can be helped in behavioural and educational development through play, and that careful choice of play material can enhance this development greatly. This opportunity should be prepared for the children, through the medium of play and play material specifically designed to onset behavioural and educational development.

7.3.4. RESEARCH TOPIC IV: THE TOY MARKET

Fraser (1972) points out that the similarities of play characteristics and interest in certain objects of infants from different nations and cultures, up to the age they start being influenced by their own cultural norms and values, reflected on the nature of toys offered to them. Besides, social values, trends and technology also create differences in the choice of toys.

Burton (1992) explains that until the 19th century, childhood was not treated differently from the rest of the human lifecycle. Children were raised with the sense of duties they had to conduct in life. The toys made for them were in that nature, as replicas of the world. The influence of the Jesuits on French education in the 17th century, the growth of family affection within the middle class in the 18th century, and the effects of industrialisation on the social structure in the 19th century changed the attitudes towards childhood (Burton, 1992). Teachers who believed in the importance of free play in childhood also had influence on the toys created for children.

EARLY IDEAS ON PLAY AS A LEARNING MEDIUM

Early ideas about play being a learning medium for children were theorised by educators such as Rousseau, Pestalozzi, Froebel and Montessori. Pestalozzi, whose theories were sense-oriented, believed that education began with sense perception and that objects could be used effectively to stimulate the child's interest in learning (Shapiro, 1983). His student Froebel, on the other hand, searched for means to unite the child's soul with the faculties of reason, feeling, volition and perception. Froebel found a correspondence between the evolution of natural forms and the stages of the child's growth, and divided the years from birth to 6 years into stages of physical and mental development: *infancy*, *early childhood* and *childhood*. For each stage he devised educational exercises. A child of 4 to 6 can display acute mental activity, which Froebel found fascinating, yet emotional and intellectual limits prevent him/her from obeying the discipline that school requires. In 1837 Froebel formulated his own school for early childhood, the *Kindergarten*, where children could *grow as flowers*, suitably for the wealth and abundance of their inner and outer lives (Shapiro, 1983). The kindergarten was a pleasant physical environment, with an adjoining garden or a sunny room with plants, animals and pictures. The desks and chairs were scaled to the size of children, leaving free space in the classroom.

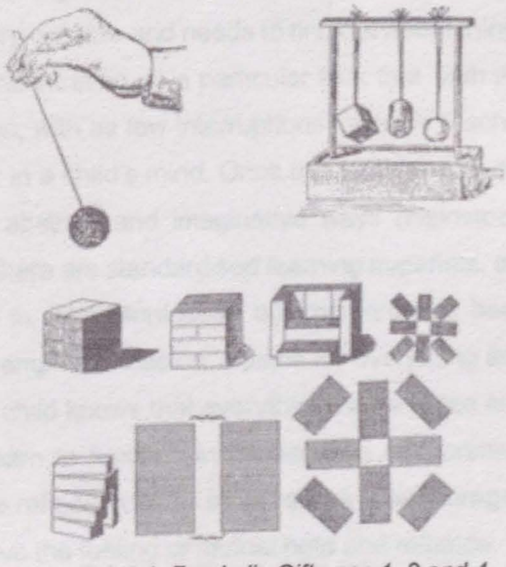

Figure 7.3.4.1. Froebel's Gifts nos 1, 2 and 4.
(Source of Figure: Shapiro, 1983: 70-71).

The space was filled with sights, sounds and objects of early childhood.

Froebel believed the child had to be given certain *gifts* starting from birth: solid geometric forms, for early sensual and physical development. The first given in infancy (*Figure 7.3.4.1.*), was the ball, whereby the concepts of *freedom* and *unity* symbolised in the motion and sphericity of the swinging ball could be experienced. Slightly older, he/she became ready to receive the more complicated gifts (*Figure 7.3.4.1.*): dissected cubes or building blocks, to learn about building. 'As the divisions of the cube increase in variety and complexity, the child finds he can produce more and more perfect forms', and learns about 'organic connection' as the 'regulator of instinctive activity' ' (Shapiro, 1983: 24). With other activities such as weaving, bead-stringing, sewing and stick-laying, the child learned to create own forms (*Figure 7.3.4.2.*). A Froebelian exercise was only complete when all the materials were returned to their containers in the classroom, this being a final concrete reminder of *God's plan for moral and social order.*

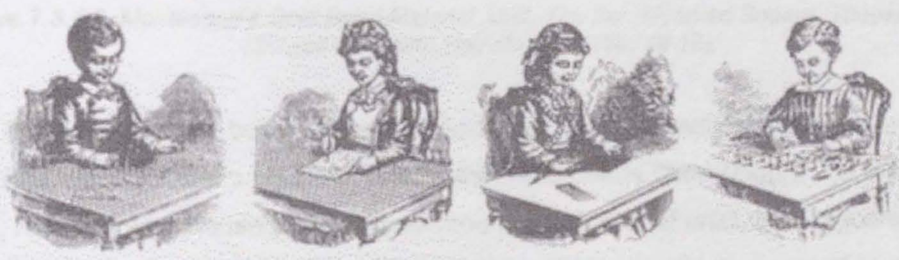

Figure 7.3.4.2. Froebelian Activities: Stick Laying, Pricking or Perforating, Paper Interlacing and Pea Work (Source of Figure: Shapiro, 1983: 74-74).

Montessori's (1870–1952) ideas developed while working as a physician in homes for retarded children and are based on providing playful learning experiences. She saw the problems as not always physiological but mostly educational, and became a supporter of early childhood education (Hainstock, 1978a). For Montessori, from birth to 6 years are the *formative years,* when the child has an *absorbent mind,* the ability and eagerness to learn unconsciously from the environment. She believed the child is cognitively very capable and needs to find out about things in his/her own *cycle of activity* - those periods of concentration on a particular task that, with the use of learning materials, to be worked to completion, with as few interruptions from the teacher as possible, to help build concrete patterns of order in a child's mind. Once this is achieved, the child can work and use these materials in more abstract and imaginative ways (Hainstock, 1978a). Although in Montessori's classroom setting there are standardised learning materials, the child is free in choosing which activity to engage in. The Montessori environment has been criticised for being too structured and utilitarian, her emphasis was on 'a place for everything and everything in its place' (Hainstock, 1978a: 35). The child knows that everything has a place and can be found there. The child is encouraged to learn to function in his/her own environment individually by the use of these materials; when more refined in those skills he/she is encouraged into social interaction within group activities to achieve the feeling of mutual help and reliance.

Montessori developed materials for motor education, sensory education, language and maths, made to be self-correcting, rather than requiring the intervening of the teacher. These were groups of objects of a certain physical quality such as colour, shape, size, sound, texture, weight, temperature, etc., each group representing a *quality* but in *different degrees*. The contrast between the extremes in the series made the differences evident and brought out the single quality (Montessori, 1988). The *Golden Bead Material* was developed as a maths learning set (Hainstock, 1978b).

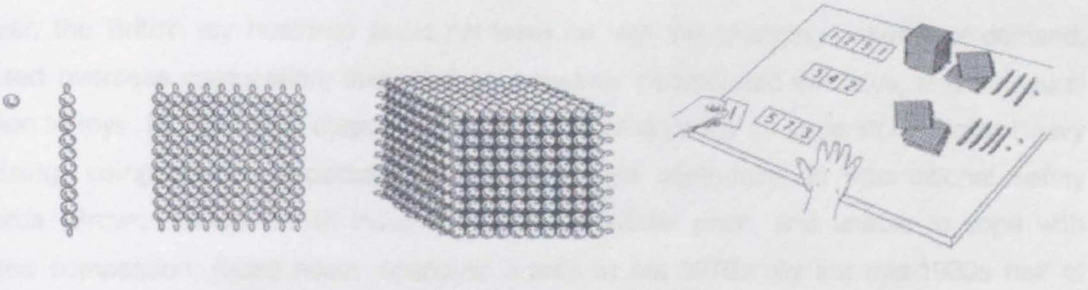

Figure 7.3.4.3. Montessori's Gold Bead Material: Unit, Ten Bar, Hundred Square, Thousand Cube (Source of Figure: Hainstock, 1978b: 18-19).

The set is made of a one-bead unit, a 10-beads bar, ten 10-beads bars to form the 100-beads square, and ten 100-beads squares to form the 1000-beads cube (*Figure 7.3.4.3.*). The terms unit, ten, hundred and thousand are represented in these sets of units, bars, squares or cubes to help the child visualise and build up high quantities. Numbers are represented in quantities and require a geometric understanding of unit (the dot), bar (the line between two dots), square (area, 2-dimensionality) and cube (volume, 3-dimensionality). The set thus addresses to, and combines visuo-spatial skills for numerical understanding.

THE BRITISH TOY INDUSTRY

The toy industry in Britain emerged in the second half of the 19th century. The years following the First World War witnessed a number of major contributors to the British toy industry, such as Lines Brothers, Meccano construction sets, Hornby Dublo train sets, William Britain's lead soldiers, Merrythought (*Figure 7.3.4.4.*) and Chad Valley soft toys (Brown, 1998). After World War II, new enterprises such as Lesney's Matchbox toys, Mettoy, Airfix plastic model kits, and

Figure 7.3.4.4. Merrythought paint workshop, women painting soft cat's eyes.
Figure from the book *The British Toy Business* by K.D. Brown, The Hambledon Press, London: 1996.

Merrythought teddy bear from 1935.
Figure from the book *Children's Pleasures* by A. Burton, V & A Publications, London: 1996.

Berwick Timpo's metal figures, emerged. With the progress of developmental psychology and the globally recognised importance of education, especially after the Second World War, toys began to reflect developmental, social and moral considerations even more, and culturally they came to reflect more global designs. Traditional toys (such as china dolls, clockwork toys, doll's houses, teddy bears, paper theatres, figurines, tin vehicles) of the West began to be treated as old-fashioned with their delicate parts, and more suitable to become collectibles, for their entertaining qualities were found to be out of date and no longer valuable for a child's free play session.

However, the British toy business could not keep up with the changing patterns of demand, increased overseas competition, technological novelties incorporated into toys, and structural evolution in toys. Multinational corporations were producing goods for superstores doing heavy advertising, using seductive packaging, and toys were conforming to international safety standards (Brown, 1996). British industry, used to a slower pace, and unable to cope with overseas competition, faced heavy economic losses in the 1970s. By the mid-1980s half of Britain's leading toy firms were owned by foreign companies, due to 'lack of innovation both in terms of concepts and material, outmoded presentation, poor product quality, and the failure to design toys appropriate to the target market or attuned to the changing nature of childhood' (Brown, 1998: 324).

THE TRENDS IN THE TOY MARKET TODAY

Chidren's play interests and behaviour change with the change in values and advanced technology; but the need to play remains. Classic toys like wooden building blokcs, fabric dolls, teddies, electric trains and board games Monoply and Scrabble are still popular as basic toys (Jackson, 1999). Also, there are still toy companies that specialise in certain toy categories or types which have survived well. Italian based Chicco (infant and pre-school toys and products), US Little Tikes (indoor and outdoor activity toys), Danish Lego (construction toys), Japanese Tomy (infant and pre-school toys, activity toys, toddler's electronics) are a few examples. Specialising in electronic learning aids (ELAs) only, V-Tech (USA) has popular demand worldwide. It should be accepted that the toy market has now been invaded by technology and interaction, and that is what the toy consumer wants today. Electronic toys with software are produced for children even as young as 18 months (*Figure 7.4.3.5.*).

Figure 7.3.4.5. R/C Beep and Bopp from the Planet Zane, by Tomy, 2000 (Radio-controlled battery-operated toddlers' robot toys); Alfie the Interactive Teddy by Vtech, 2000.

Infant-friendly ELA toys and children's computer popular recently, now produce interactive electronic toys for children as young as infants and toddlers, and give emphasis on interactive software –CD-ROMs that go with characters, toys and games (*Figure 7.3.4.6.*).

Additionally, the dramatic decrease in card and board games sales led their producers to search for ways of modernising, with certain adjustments such as being more three dimensional, or incorporating interactive electronics. The same situation is valid for construction toys, which now involve not only standard components, but also different coloured and shaped pieces, enabling children to construct organic and abstract forms. Lego has had to incorporate motorised and electronic components to activate its building sets. K'Nex and Tiger also produce radio-controlled construction kits. Children now not only construct their own vehicle, they can operate them as well.

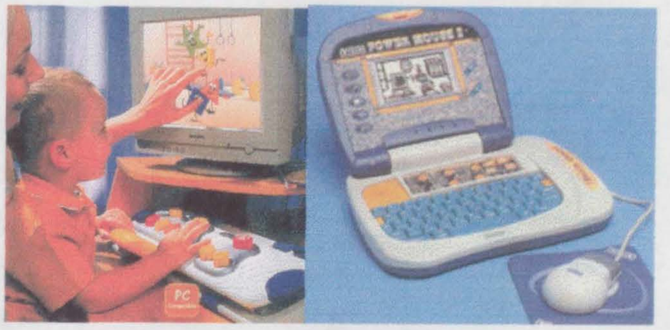

Figure 7.3.4.6. The Baby Keyboard by Berchet Media and Early Learning Centre, 2000; Vtech Power Mouse II.

To keep up with the technology employed in toy industry, toy companies have transformed into giant corporations from the once modest businesses. Today, the two US based companies, Mattel and Hasbro, largely dominate world toy industry and markets, basing their marketing strategy on acquiring toy companies that produce for different toy categories, so as to cover a wide range of children's products. Mattel, the leading company in girls' toys, has recently acquired Fisher-Price, Spears, Tyco and Bluebird. Hasbro, that holds the world's highest shares in boys' toys, owns brand names such as Action Man, Mr. Potato Head, Playskool and K'Nex, and also has license rights to Batman and Robin, Star Wars, and the Pokemon Trading Cards.

Figure 7.3.4.7. Machine Man by Masaduya, 1950s; Buzz Lightyear from the Walt Disney/Pixar movie Toy Story, *1995; The Mind Storms Range by Lego, the computerised construction set, 2000.*

Neither Hasbro nor Mattel have outlooked the latest trends in children's games. Hasbro's sub-branch Hasbro-Interactive prepares educational and lifestyle software. Mattel, on the other hand, owns websites such as 3DGreetings.com, Printshop.com and FamilyTreeMaker.com. Also, Mattel prepares games and entertainment software to go with the characters and games it produces. Japanese Bandai owns the licence to 2000's great success Pokémon, the Power

Rangers of a few years earlier, the Tamagotchi pocket pets, and Betty Spaghetty, the girls' fashion doll slightly different in looks and concept to other fashion dolls. The Japanese toy industry is particularly involved with robots and robotics, a favourite with children even before the launch of the first space rockets (*Figure 7.3.4.7.*).

The latest trend in robot toys has been inspired by the actual robot dog AIBO, the smart toy produced by Sony, in Japan (*Figure 7.3.4.8.*). The computerised AIBO robot dog is programmed to learn a few commands, and display six emotions (anger, sadness, happiness, fear, surprise and dislike) by using sound, melodies, body language and light from eyes and tail, requiring full-time occupation. AIBO picks up images and sounds, and may react to them; it will also 'learn' from praise and scolding, and play with its pink ball that comes as an accessory. AIBO's four sensors, touch, hearing, sight and sense of balance, make its movements correspond anatomically to that of humans and animals. AIBO's experiences and what it 'learns' are recorded in a memory stick. The robot dog has obviously caused great excitement among children; the toy industry has launched cheaper primitive alternatives (*Figure 7.3.4.9.*), such as Poo-Chi Robotic Dog by the US-based Tiger Electronics, and Teckno Robot Dog by Manly Toy Quest.

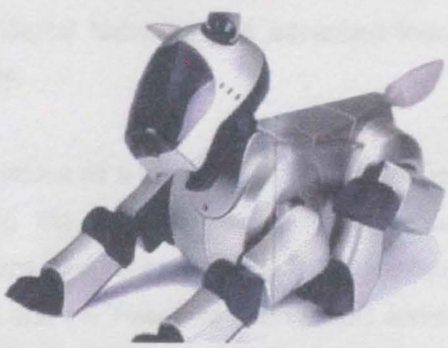

Figure 7.3.4.8. Sony AIBO Second Generation, 2000.

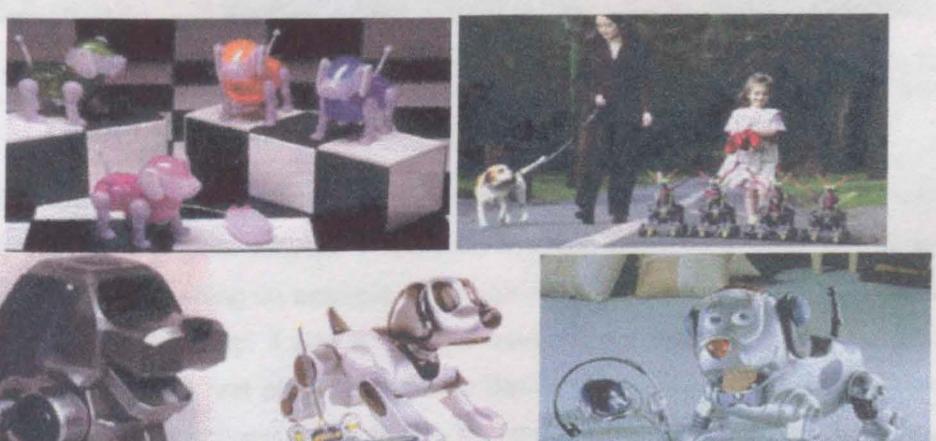

Figure 7.3.4.9. From left to right and first to second row: I-Dog by Tobar Ltd; Cyber K'Nex; Poo-Chi by Tiger Electronics; RoboNagi By Toy Options; Robotic Puppy by Fisher-Price.
All launched in 2000. The I Dog is controlled by a mouse-like switch to do very basic movements. The K'Nex dog comes as a set to be constructed.

Currently in the UK, there is more interest in interactive toys (such as Furby or Poo-chi) or toys and accessories that belong to an established game (such as Pokémon). The Pokémon from Japan, first introduced as a video game that became popular, was made into TV cartoon series; Pokémon collecting and trading cards, figurines and accessories followed. In October 1999

Pokémon had its first movie. The Pokémon fact made the toy industry accept that video games could no longer be excluded from toy category lists. Toys were now made from a video game (not a video game from existing characters). Pokémon video games (by Gameboy, Nintendo – Japan) occupied the first five rankings of entertainment software titles sold by units in the US (source: NPD TRSTS Toy Tracking Service, TMA Website). The entertainment software producers are Sega (US), with its Dreamcast Console, Nintendo (Japan) and Sony (Japan) Play Station, which launched Play Station 2 in 2000. Digital technology is advanced today, and interactive software constantly increases in popularity.

A major movement in the toy industry in the past decades as a main drive for new products, has been the emergence of character licences giving the rights to market toys, games and accessories of characters created for TV series or films. The recent contribution of the British toy industry has been the Teletubbies (*Figure 7.3.4.10.*) and the Tweenies (from CBBC series). The British toy industry has also seen the launch of two new companies into the market; Rumpus, which offers a wide range of toys, and is mostly known for its original designs in interactive soft toys; and Wow Toys, which produces infant and pre-school toys (*Figure 7.3.4.10.*).

Figure 7.3.4.10. Dancing Teletubbies by Golden Bear Products Ltd, 2000; Tumble 'n' Rumble Twins by Wow Toys, 1999; Wake Me Willy by Rumpus, 1999, a soft toy clock that can be taken to bed, and tells the time when the nose is touched.

Girls' fashion toys, such as the Barbie doll (*Figure 7.3.4.11.*) on the other hand, remain classic, without change of the original concept. The Barbie doll, first launched in 1959, aimed to reflect a modern young woman, setting an example of how girls of the sixties' should grow up. Compared to paper figurines to dress up, it was a different solution as a fashion doll, for it had a proper young woman's body, the first of its kind. Today Barbie (from Mattel) is a doll indulged with a fairytale-like world of materialistic goods. Before Christmas 1999, Tesco and Asda (UK superstores) actually requested Barbie and Steffi (an alternative fashion doll from Hong Kong based Simba) manufacturers to make more full-figured dolls to help cut out eating disorders among female children (UKTN, November/December 1999). With changing contemporary social structures and values, Cindy, Barbie's UK cousin (first launched by Pedigree, today by Vivid Imaginations) has been

Figure 7.3.4.11. The Millennium Barbie by Mattel, 2000.

relaunched with a new working girl concept, the Animal Hospital Adoption Centre and Emergency Rescue Cindys. Tanya, launched for the first time in 1999 by Toy Options (UK) is a *walking doll*. She is trendy and sporty and 'with attitude' as the suppliers suggest, and the Tanya models offer the following: Babysitter Tanya, Shopping Trolley Tanya, Holiday Tanya, Body Training and Aerobics Tanya.

As the Barbie category of dolls have history behind them, which can be altered to the child's whim with changes of clothes and setting offered alongside, so there are other toys, particularly character dolls presented with a background story complete with a scenario and the accompanying accessories. The Space Sprogs were launched in 2000 within a similar concept (*Figure 7.3.4.12.*): the tiny friendly aliens looking for safety and food supply and escaping enemy travel to Planet Earth. These creatures are collectibles, having individual qualifications for the story and have games software and a website (www.planetsprog.com) of their own.

Figure 7.3.4.12. Space Sprogs by Planet Sprog, 2000.

Today it may be difficult to come across a toy that does not *interact* with the child in diverse forms such as flashing lights, sounds, vibrating movements, etc., as one play aspect is not enough to keep a child interested. A good example for a traditional toy that had to evolve into a new concept is the boys' toy action figure. G.I. Joe and Combat Carl are early examples of action figures, followed by the Action Man, Space Rangers and the like. But what the last decade has brought to action figures as novelty is their *transformation* into other forms for heroic activities (as in *Figure 7.3.4.13.*).

Figure 7.3.4.13. Autotech Vehicles into Robots by Toy Options, 1999.

Facing these changes in trends and technology in the toy industry, it is doubtless that the culture of childhood is changing. Children particularly in Western cultures grow faster as they have access to TV, computers and latest technological developments, and once they start school, spend less time on playing with toys (UKTN, February 2000). Their heroes are no longer cartoon characters created for them, but are TV personalities, sports and pop stars, who seem to be what today's children aspire to. As children grow up younger, toys are short-lived as well. Schogger (1999) reports that toys that were suitable for 5-year-olds in 1990 are now suitable for 3-year-olds. Also there does not seem enough time to form an attachment for a toy; children lavish interest on the stories behind the toys, which keep altering.

To conclude, the latest concepts in the toy market thus involve interactive media for children: they represent a story and the figurines, accessories, hardware and software are produced accordingly, children building their play around the given material. In disagreement with Dixon's (1992) belief that this may limit imagination, the story behind the toy does give a strong basis for imaginative play for children, encouraging abstract thinking, creative thinking, problem solving and co-operating with peers, as long as the children are free to choose how they play with the toy. Children with blindness/visual impairment however, are a step behind in the use of contemporary toys and games. Although they may handle the novel toys, the story, hardware and software may not be adapted to their needs and understanding, thus leaving them out of the cognitive, imaginative and social benefits of the particular play. There is a great need in the toy industry for the development of toys for children with special needs. A primary way to achieve this, is to design toys with novel concepts, taking as a starting point children with special needs, and to try and incorporate into the design clear, understandable, attractive and up-to-date features. Any toy so designed should also offer play value to children with no disabilities as well, thus addressing the play behaviour of both groups of children, who through common play, can achieve social contact and development, that will help them in future real-life situations.

TOY RELATED ACCIDENTS AND TOY SAFETY REGULATIONS

The last complete statistics available (1994) estimate that there are about 50,000 toy related accidents in the UK each year (BTHA, 1997), half of them falling off a toy; around 16,000 from toys being thrown. Falling over toys left lying around, or broken toys still being used, also comprise a large number. Other reasons are the unsuitability for the child, and abuse of toys in extreme ways. Accidents caused by the toy itself due to bad design and poor production quality are around 2-3% of the accidents in total, falling into four broad categories (CAPT Factsheet):

- Choking (By swallowing small pieces or loose parts)
- Poisoning
- Burns
- Cuts, bruises and fractures (by falling off, or being hit, or running into toys, etc.)

The toy consumer has gained consciousness in safety issues in toys, especially since the 1970s. Swartz (1971), a US lawyer who represented toy-related accident victims in court, explained the reasons why toy safety regulations were necessary as, bad design, poor production quality, wrong choice of materials, inconsiderate and irresponsible ideas, dangers of direct selling to children due to age inappropriateness, no pre-market testing, no age warnings on toy packages, unsafe packaging, unhygienic toys, and, psychologically harmful and unethical toys. It was necessary to control and regulate confusing and misleading claims by manufacturers in ads or packaging (such as the term '*supersafe*'), and ads on TV and in posters showing children using or bystanders posing with the product in unsafe positions (*Figure 7.3.4.14.*). It was also necessary to assure standard procedures applied in individual testing laboratories and standard guarantee of safety on all toys as a guide for parents in selecting toys.

In the UK, toy safety is under the control of the Consumer Products Safety Commission since the 1950s. The first UK safety regulations, the BS 3443, came into operation through public pressure, in 1961. Today the valid safety standard in the UK is the BS 5665/BS EN 71[7], which also conforms with the European Toy Safety Standards. The standard applies to toys for children up to the age 14. Today toy safety regulations directories try to cover unimaginable and extreme circumstances, and update their regulations as often as necessary.

Figure 7.3.4.14. Sears swing presenting the use of the swing in an unsafe manner, in a print advertisement from the 1960s, USA.
Figure from *Toys That Don't Care* by E.M. Swartz, Gambit Incorporated, Boston: 1971.

The main requirements for the launch of new toys are that they must be safety tested in their entirety, be accompanied by warnings where necessary, bear the necessary name and address details, and the CE marking (Intertek Testing Laboratories Factsheet, 1997). Toys bearing the CE mark conform to the safety standards in the EU Toy Safety Directive, just as other products bearing the CE mark conform to related safety standards (*Figure 7.3.4.15.*). On the other hand, the Lion Mark is of safety backed by a strict code of practice used in the UK (*Figure 7.3.4.15.*) to signify that the toy has been manufactured to British Standard BS EN 71. Second-hand toys too have been subject to safety regulations since 1967 (BTHA, 1997). Such toys must satisfy the updated safety provisions but are not subject to CE marking and name and address requirements.

Figure 7.3.4.15. The Lion Mark and the CE Mark from a toy packaging.

[7] The BS 5665/BS EN 71 Toy Safety Regulations Directive is structured under the following parts:
- Mechanical and physical properties [BS 5665 Part 1 (1997)]
- Flammability of toys [BS EN 71 Part 2 (1994)]
- Chemical properties [BS EN 71 Part 3 (1995)]
- Specification for experimental sets for chemistry and related activities [BS 5665 Part 4 (1990)]
- Chemical toys (sets) other than experimental sets [BS EN 71 Part 5 (1993)]
- Graphical symbol for age warning labelling [BS EN 71 Part 6]
- Safety of electric toys [EN 50088]
- Specification for cleanliness of fillings and stuffing for bedding, upholstery, toys and other domestic articles [BS 1425 (1960)]
- Specification for model steam engines and internal combustion engines for models [BS 7328 (1990-1995)]
- Specification for luminaries and child-appealing luminaries [BS 4533 Part 101, Part 102 (1990)].

The directive includes requirements for radioactivity as well.

Thus, a toy launched into the market has already had safety measures incorporated into its design as much as hazard scenarios have been able to foresee and has been thoroughly tested. The user/carer is informed about residual risk that cannot be removed by design as warning information on the packaging and instructions (*Figure 7.3.4.16*). The second stage of safety measures involves the user/carer's foreseeability and implementation, and the child's access to the hazard can be limited or prevented by supervision, barriers, harnesses, etc.

Figure 7.3.4.16. WARNING on a toy packaging.

All the same, passing safety testing does not mean problems will not occur. There may be points that are overlooked, or that pass certain tests but fail in real life situations. Since 1976, there have been more than 1000 toy and children's product recalls officially announced (Source: Consumer Products Safety Commission (CPSC) Website) (*Figure 7.3.4.17*).

Figure 7.3.4.17. Product Safety Recall by Playskool, published in The Sunday Telegraph, October 17, 1999.

The absence of injury or accident history does not mean the toy should be presumed to have a low level of risk. Risk is a combination of several factors, and in risk estimation, extreme scenarios should be kept in mind. Risk in this case means 'the combination of the probability and the degree of the possible injury or damage to health in a hazardous situation' (CEN, 1999: 74). Hazard is a product characteristic, which is a potential source of harm that could lead to injury. Risk estimation involves evaluation of the severity and of the probability of an injury. To help assess the risks that a product may possess, the following questions may be asked (CEN, 1999):

1. What is the intended use: Who will use the product, and under what conditions? This question raises issues such as normal age-related behaviour, development and ability of the child.
2. What is the foreseeable use: Would the product be used in another way than intended, particularly by children younger or older than the intended age group? Would the product be mistaken for something other than what it is? Would the product be used simultaneously by two or more children?
3. In which environment will the product be used: Indoor and outdoor climates will differently affect the product. Also, the likely interaction of the product with other objects has to be considered.
4. Will the product be used with the child attended or unattended?
5. How long a time will the child be exposed to the experience with the toy?

To conclude, toy safety regulation directives have brought about a drop in the percentages of accidents due to poor design and production quality (BTHA, 1997), though, this in itself has not been enough to prevent accidents entirely; which brings home, the importance that must be given to the conscious selection of toys, their regular checking and proper stacking, as well as attending to the children at play. Careful supervision and vigilance is especially important for children with special needs in play situations, because of their limited bodily capabilities, and slow reflexive reactions, and the possibility of their using toys in ways not intended.

THE TOY CONSUMER AND ETHICAL ISSUES IN TOY CONSUMPTION

The population of children has demonstrated a slight rise in the UK over the last ten years, suggesting that the toy market is expecting a steady increase in toy purchase, particularly for the 5–9 years age group (BTHA, 2000). Adults too, buy collectibles and plush animals for themselves (BTHA, 1997). Incomes, prices of the toys and seasonality of purchase all influence the toy consumer. Changes in family structure have been a major influence (Brown, 1996): Family income has increased with mothers also working; families are smaller, with less children, this increasing the money to be spent per child. Also, higher divorce rates mean two sets of gifts for special occasions. Advertising pressures have made the economically limited families too, buy toys as gifts. Another major influence on the purchase of toys is TV advertisements, aimed to catch mothers and children watching TV at the same time, particularly as Christmas approaches(BTHA, 1997). The attractiveness of the packaging for the child, and the convincingness of the product for the mother are the main PR tactics of the toy manufacturers (Schogger, 1999). For children under 5, the direct target in advertisement is the parents, and for older children, it is the children themselves. Regulations have been brought upon TV advertisement broadcasting, for ethical reasons. In the UK, the limit for a TV ad for toys is 20 seconds. The products have to be presented as they are, and not give an impression of doing functions they actually do not do, or used in a dangerous way, which may influence the way the children might want to use them. The prices have to be shown.

War toys, sexism and racism in toys involve ethically sensitive issues. War toys and games may be toy weaponry, miniature armies, tanks, ships and planes. They can also be board, card or table-top games for more than one player. Such toys have been subject to criticism, mainly because of the devastating consequences that war brings to nations, and that war should not be taught to children as being a natural thing and a source of fun. Some of the early examples of video games, now home entertainment, were war fighting where the player would be in control of weapons to chase and attack objects on the screen. Naiman (cited in Dixon, 1992) pointed out that these toys teach automatic responses in children, by learning to respond to stimuli, resulting in automatic obedience useful in warfare.

War games have become less popular in the past two decades, though toys suggesting aggressive play have not. Toys such as action figures who fight against terrorists or against danger from outer space, from evil aliens, or wrestling figures of stereotyped strong male characters, stand for aggressive fighting represented in play. Video games too, not only involve shooting at, but missions such as search, rescue and escape which bring other skills into operation. Fight and aggression in toys and games disguised under heroic reasons, along with increasing life-likeness of toy weapons, is being a target of criticism and constitute a major ethical issue.

Another ethical issue for the toy industry to address with care is, sexist toys which bring strong differences in gender roles and stereotypes. Dixon (1992) stresses that the messages encoded in toys for boys and girls differ strongly. While the Barbie doll is physically pretty, and is made to pose, the Action figure is strong, muscly, and is made to look ready to enter a fight. Dixon points out that even the lettering on the packaging and logos, and the TV ads, suggest a sex difference: the action figures are represented with sharp, bold letters and the music and images on the TV ads suggest loudness and movement. Girls' dolls have thin, softer, smoother lettering, and pastel colouring, with gentle music on the TV ads, suggesting domesticity, or romance. The male doll is the breadwinner and fighter, the female doll is the homemaker and self-groomer (Dixon, 1992). The major concern here, is that toys suggest inequalities in gender.

Perhaps as a reaction to such stereotypes, particularly in children's TV series and cartoons, the heroes have lately become more down-to-earth, ordinary persons, or children themselves. The toys and figures of those characters too have been launched into the toy market, presenting more realistic and less stressful values for the children who buy them. There has also been concern regarding toys that ridicule ethnic groups, or suggest the inferiority or minority of races. The toy industry has responded positively to the offended toy consumers; let's remember that we do not find Golliwogs anymore among children's newly produced toys. For multicultural societies like Great Britain, it is also important to produce or import toys that have ethnic or cultural value.

It is possible to say that there is cultural imperialism through children's playthings (Dixon, 1992). There are few countries which are major producers and distributors of toys: USA, UK, Japan, Germany and France. In consequence, cultures of childhood in nations around the world are becoming more and more similar, and children from different cultures are growing up with similar aspired values and interests, some of which are too materialistic and so subject to questioning.

Another ethical issue lies in the marketing strategies of toy companies (Dixon, 1992). Companies are producing toys according to the artificially created wishes of children. It is difficult to say if the toys of today are made for children's actual needs. One strategy is killing off a toy when it reaches peak sales, by not providing enough supply to retailers, subsequently replacing it by a new launch. To provoke interest and ensure continuous sales, toys are produced with a ready story and characters, accessories, dresses, vehicles, houses and play sets are all made to go with it. There are fan clubs of toys, with badges, T-shirts, newsletters, and the logos and characters are licensed for clothing, bags, shoes, bikes, lunch boxes, pencil boxes and stationery, bed wear, wallpaper, cutlery and crockery, etc. Dixon (1992) criticises all this, saying the toys no longer provoke imagination, but make playing a repeated ritual.

Another sensitive matter concerns the labour conditions offered by large toy companies that have their products manufactured in developing countries, where labour is cheap. Due to questions arising on working conditions in these factories, the BTHA published a vendor and sub-contractor code of conduct to assure safe and fair working conditions in the factories, and for store workers.

Disability is another sensitive issue to be addressed by the toy industry, and toy characters with disabilities have been launched, such as the Wheelchair Barbie. Particularly since the 1990s, another issue has been brought to the attention of the toy market: toys for children with special needs. In view of the short range of choice of such toys or their inadequacy, in selecting toys for children with special needs, parents may find it difficult to decide on what toy to buy. As the abilities and interests of children with special needs differ, and bearing in mind that speciality toys are highly priced, parents would like to make sure their child would play with a purchased toy. In 1972 the Toy Libraries Association was founded to help families with handicapped children with play material (Dixon, 1992). In 1984 the Association extended to Play Matters/The National Toy Libraries Association. Rather than investing in a certain toy, member families can borrow toys from toy libraries according to their child's changing needs and interest. However, the question of furthering the toys for special needs children and making them available on the market in a wide range, is a standing one that awaits tackling.

7.3.5. RESEARCH TOPIC V: THE TOY MARKET FOR CHILDREN WITH SPECIAL NEEDS

Since the early 1970s schools were founded specifically for children with special needs. With the Education Act of the 1980s, integrated education is now provided in some schools for families who prefer their special needs children to attend mainstream schools. Integrated education encouraged educators, parents and psychologists to search for ways for special needs children to play with the same toys and playthings as their peers, to be able to go through the same experiences as them, to be familiar and updated with ongoing activities, and to share a common medium. On the other hand, the importance of play with rehabilitative and therapeutic toys for the special needs child is also being stressed, and there have been attempts to develop toys in that vein. The outcome of those attempts were either toys that had only therapeutic value, or those adapted from toys made for children in full capability (Gielen *et al.*, 1998), or those designed and manufactured as a prototype to be given to a single child (Henze & Sibbel, 1984; cited in Gielen *et al.*, 1998). With the 1990s, there have been attempts primarily in Germany, Sweden, Denmark, the Netherlands and the USA, to search for ways to develop toys with rehabilitative aims to be played in a free, and not merely therapeutic manner. At present, the British toy industry does not show a marked evidence of development of toys for such a target group, apart from a few British companies producing specialist toys, with mainly therapeutic value. The argument is that, with the safety considerations, developed technology and use of different materials and details, from among the toys available in the market, there can be found suitable ones for children with special needs as well. Although this is true to some extent, the toys in the market may not have the same intended beneficial effects on children with special needs as they have on children of full ability. Today most toys are produced in plastic as it lowers the prices, is easy to mould and comes in a wide range of colour options. Yet it always results in the same touch, giving very limited experience of finishing texture, if any. This for instance, is a main reason why the toys available in the market do not have the same informational properties for children without sight as they do for children with sight. Obviously, there is need for toys for children with special needs, developed around novel concepts specifically addressed at this issue.

TOYS FOR CHILDREN WITH SPECIAL NEEDS OFFERED ON THE MARKET

Toys found in the market today, concerning children with special needs in general and, blind and visually impaired children in particular, can be discussed under three categories:

- Toys and games addressing gross-motor skills – for bodily activities
- Toys and games addressing fine-motor skills – for the hand: touchy–feely toys
- Toys and games for learning:
    - Cause-and-effect toys
    - Replicas of things
    - Electronic learning aids.

Toys and Games Addressing Gross-motor Skills

As has been discussed in *Research Topics I* and *II*, using the body as a whole in co-ordination may not be easy for some children with special needs. Totally blind children may also need to have their posture and walking corrected for more independence. Toys and equipment produced by specialist companies may be used in physical or sensory therapy sessions. These may be from mild massages and exercises to more specialised therapies for balance, tracking, or mobility. Walkers, push and pull toys, pedalling toys and ride-on toys may all be considered as steps towards independent sitting, standing and walking. Sports props such as trapezes, balls to throw, roll and catch, or swimming materials may also improve the use of the body. Garden or indoor activity toys such as swings, slides, climbing bars or modular spatial elements arranged to form spaces, water pools, sand boxes and ball pools, may also be considered as toys encouraging gross-motor movements and giving bodily stimulation. Children with physical difficulties may thus be encouraged into play behaviour with the use of therapeutic/rehabilitating play material, by specialised toy manufacturers[8]. As this subject covers a wide range, this section will mainly illustrate toys and props addressing skills of the legs and feet, also to guide children with visual impairment with independent walking.

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[8] Rompa and TFH in the UK today are the largest manufacturers and suppliers of specialist products ranging from toys to furniture, adaptable switches to relaxing music.

Balance domes may help the child in maintaining balance in all directions, or to two sides only (*Figure 7.3.5.1.*). If standing up is difficult in the beginning, the child may also sit on the dome tray. The walking rope consists of round mats connected with ropes, arranged at the desired direction and distances apart (*Figure 7.3.5.2.*). The mats contain 0 to 9 knobs, which can be felt under the sole, and the child can arrange steps and direction to follow the mats. The modular tactile sole sensation mats of plastic, wood, carpet, ceramic, foam or hemp, are a series of squares attached to each other to form walking paths (*Figure 7.3.5.3.*).

Figure 7.3.5.1. Therapy Dome by Rompa.

Figure 7.3.5.2. The Walking Rope by Rompa.

Figure 7.3.5.3. Tactile Sole Sensation Mats by Rompa.

The musical foot mat is a foot operated electronic mat responding to touch (*Figure 7.3.5.4.*). The child can walk on it to create sound patterns, or if lying on it, can use body and arms to obtain rewarding sounds. A similar concept is offered by the Hopscotch model of the musical pads by TFH (*Figure 7.3.5.5.*). The shapes on the mat are connected to a speaker and each gives out individual sounds, as the child moves on them or pats them. The Musical Hopscotch Pad consists of eight different coloured foam blocks that make individual sounds, and a panel of eight coloured light squares that illuminate when the corresponding block is stepped on (*Figure 7.3.5.6.*). The interactive stepping stones are modular foam blocks of different height (*Figure 7.3.5.7.*). Moving from step to step activates a spotlight of corresponding colour in the environment.

Figure 7.3.5.4. Musical Foot Mat by Rompa.

Figure 7.3.5.5. Hopscotch by TFH.

The Optimusic system of light beams create musical sounds by movement (*Figure 7.3.5.8.*). The brightly coloured light beams project onto the floor, and as the beams are interrupted by movement, a musical note can be heard. The sound can be arranged as to that of any instrument. This system helps to discover the relation between the light beams, the user's own movements and the sounds, thus creating an interactive environment that the user can command and manipulate.

Figure 7.3.5.6. Musical Hopscotch Pad by Rompa.

Figure 7.3.5.7. Interactive Stepping Stones by Rompa.

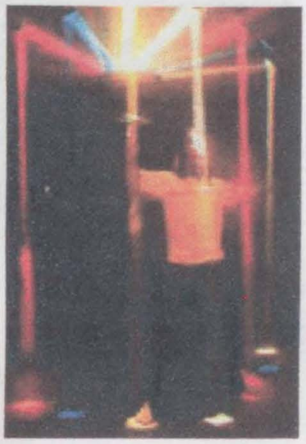


Figure 7.3.5.8. The Optimusic System.

Toys and Games Addressing Fine-motor Skills

This category of toys are particularly useful for visually impaired children, addressing their tactile senses. Toys that have different features, textures and stuffing to feel, will encourage hands-on experience and discovery for the visually impaired.

Apart from toys to handle, feel and mouth, there may be activity blankets with details to feel (*Figure 7.3.5.9.*). Some also react to touch and make sounds or tell stories. To develop sensitivity to tactile qualities, dominos may be used (*Figure 7.3.5.10*). Such games may also be played with rules, and in turns with others

Figure 7.3.5.9. Activity Blanket by Chicco, 1998.

A well-liked toy (recommended in the 1995 Toy Catalogue published by the RNIB) is the Jibba Jabber doll (*Figure 7.3.5.11.*). The male and female dolls have distinctive features and are composed of different materials yielding different feels. While the body is of soft fabric and filling, the head and hands are plastic, with five fingers on each hand to count, a large nose, hard ears, and furry hair. The dolls can be grasped by the neck and when shaken, make a squeaky noise that gives them their name. Having the doll in female and male versions may give children a basic introduction to gender. Another touchy toy is Flubber (*Figure 7.3.5.12.*), a large green soft character that wobbles and giggles when touched. The toy is stimulating in the sense that it responds to activities from the child's part, and vibrating movements give a kinaesthetic sensation enjoyed by most visually impaired children.

Figure 7.3.5.10. Tactile Domino by Jocdi Goula, 1998.

Figure 7.3.5.11. The Jibba Jabber doll and Ms Jibba Jabber by ERTL, 1994-95.

Figure 7.3.5.12. Flubber by Walt Disney.

As visually impaired children may be physically less boisterous and slower in responding to activities, fast moving toys or those that escape the child's clutches may be frustrating and children may lose interest. The large Little Tikes cars, trucks and vans do not roll away easily as their wheels are of a grippy texture, they are easy to clutch and manoeuvre, sturdy enough to carry the weight of a child, and easy to locate when searched for (*Figure 7.3.5.13.*). Their finish is not glossy, and the texture is quite grippy, compared to other shiny smooth plastic vehicles.

Figure 7.3.5.13. The Little Tikes cars and truck, 1998.

Figure 7.3.5.14. Animal Piano By Chicco, 1998.

Figure 7.3.5.15. Light and Sound Ball by Early Learning Centre, 1999.

Figure 7.3.5.16. Pop-Up Castle by Chicco, 1998.

Visually impaired children may not develop fine-motor skills until later ages. Musical toys may well encourage them to use their hands and fingers. These may be keyboards that require finger movements (*Figure 7.3.5.14.*). The child who finds single finger movements difficult or has limited use of the hand, may be encouraged to use fist or palm instead, to activate toys (*Figure 7.3.5.15.*). Toys with large keys separately located and easier to perceive, may be used for clumsy hand movements. For hand dexterity and eye-hand co-ordination for the sighted or partially sighted, and for gross- and fine-motor skills, pop-up toys may be useful (*Figure*

7.3.5.16.). The child may watch out for popping-out objects, target them and apply physical force to pop them back in. The toy is easy to play with for children with problems in fine-motor skills, is stimulating to the eye, and easy to observe the effect that the child makes.

The Lick and Stick Lizard guns (*Figure 7.3.5.17.*), also useful for eye-hand co-ordination for the sighted child, visual dexterity and fine-motor skills, need to be triggered with the forefinger to extend the sticky tongues to catch insects.

Figure 7.3.5.17. Lick and Stick Liz<ards by Early Learning Centre, 1999.

For the child who has difficulty in fine-motor skills related to the hand, easier games requiring less precision can be chosen. The Piggy Pick Up (*Figure 7.3.5.18.*) has a bouncy large pig to be grasped with both hands. The child has to bounce the piggy on flat bits of mud (a card game where at later stages the child can count the collected points with a peer) to pick them up. This game encourages eye-hand co-ordination, visual dexterity for the sighted child, and motor skills (balancing of the bounce, to be able to catch the ball).

Figure 7.3.5.18. Piggy Pick Up by Early Learning Centre, 1999.

The Springy Spiders (*Figure 7.3.5.19.*) may be easier to cope with, for children with movement limitations. The spider can be attached to the child's wrist, thus eliminating the need for fine-motor movement. With the movements of the arm, the spider's legs can pick up flat bugs from the floor. Then on a surface, the child will have to remove the bugs from the sticky legs, using both hands in co-ordination and using the pincer grip. This game can also be played in group sessions, and by children in wheelchairs.

Figure 7.3.5.19. Springy Spiders by Early Learning Centre, 1999.

Another game played on table top for fine-motor activities is the Grasshoppers (*Figure 7.3.5.20.*), made to hop into the tub with the use of forefingers. This activity encourages eye-hand co-ordination, visual dexterity, and fine-motor skills through the use of forefingers for precision.

Figure 7.3.5.20. Grasshoppers by Early Learning Centre, 1999.

A toy that may encourage particularly visually impaired children reluctant to insert their hands into soft things may be Harry Hairball (*Figure 7.3.5.21.*), a large soft cat with a wide mouth, which is actually a pocket. From the mouth, the child can pull out a mouse, a parakeet, a goldfish, a woolly yarn and hairballs.

Figure 7.3.5.21. Harry Hairball by Rumpus, 1999.

Figure 7.3.5.22. Soft Stuff Crazy Creepy Crawlies by Early Learning Centre. 1999.

As mentioned, visually impaired children in particular, may react to touching soft materials like clay that change shape, in a basic instinct of self-protection. The Soft Stuff Crazy Creepy Crawlies (*Figure 7.3.5.22.*) is a set of play clay that includes mouldable and reusable soft non-stick clay, and hard plastic pieces for moulding and shaping imaginary insects. The set also includes plastic eyes, wings and tails. A child can create creatures of own imagination, and having soft and hard materials together may be a gradual introduction to using fingers in mucky activities.

To help getting used to 'mucky' activities for future real-life tasks such as preparing food and cleaning with wet material, sponge-painting kits (*Figure 7.3.5.23.*) may be useful. The ready shapes of sponge are inserted into paint plates, then pressed on to paper to leave their marks. Afterwards the sponges have to be washed to get rid of the paint. This is a fast, easy arts and crafts activity also used in nurseries. Such graspable tools and material may also be handled by children with limited use of hands.

Figure 7.3.5.23. Sponge Painting Set by Early Learning Centre, 1999.

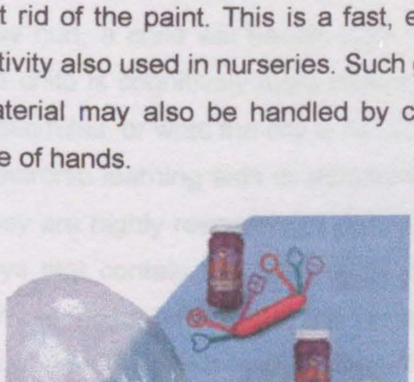


Figure 7.3.5.24. Bubble Blower Sets by Early Learning Centre, 1999.

Children with limited use of hands, develop self-feeding skills rather late. Other children with special needs may have problems in using the mouth for skills like articulation. The widely available bubble blower toys (*Figure 7.3.5.24.*), or musical toy instruments such as a trumpet, may encourage mouth articulation. For children with no hearing, the bubble blower may help the child see the effects of the blowing activity. The bubble blowing task, in addition to mouth articulation by blowing strongly yet gently enough to produce bubbles, also requires skills of using hands in co-ordination and eye-hand co-ordination.

Toys and Games for Learning

A basic understanding that a child must develop, is the relation between cause-and-effect, as explained in *Research Topic I*, under *Cognitive Development - Causality*. The toys offering to teach this relation may be as simple as sound toys, toys that flash lights when a knob is pressed, pop-up toys, or moving toys. Or, they may be more complicated in the task they require, and offer a rewarding effect in the end, when the task is accomplished. The toys may also give clues as to what happens when the child does something, such as the posting toys which make a throaty sound as the object slides down the tube they are inserted into.

Another group of learning toys would be, replicas or small models of homes, objects, cars, even household appliances, tools and food. As mentioned in *Research Topic II* under *Play Intervention and Techniques – Symbolic Play*, argument is that, such toys may not produce beneficial effects for children with no sight. Indeed, small models of objects, as exact replicas with the same construction of elements, the same material and touch in a smaller scale, will not be informative on the nature and function of the real object (Millar, 1994). But models and replicas of houses, household appliances and tools, even plastic foods that smell, have a different context when they are used together in a scenario. Such toys may help teach children with no sight what Mummy does while she is out shopping, or how she does the cleaning, or cooking, or what Daddy does in the shed to build a wooden box to put toys in. As long as the potential dangers of the real versions of these toys are taught as well – that an iron or stove will be very hot when used, vacuum cleaners are plugged into electric sockets, and hammers are heavy and may hurt, a child will benefit from their use. When the child is cognitively more mature, such models in smaller scales may also be used to teach traffic rules, or what the city is composed of, etc., as is done in many schools for the blind.

Figure 7.3.5.25. Alphabet Phonics Teacher by VTech Electronics.
Also recommended in the Kids Out Good Toy Guide, 1999/2000.

Electronic learning aids or educational toys can be found for children as young as 18 months. They are highly responsive to action from a child's part, with flashing lights, music and speech. Toys that contain the print letters of the alphabet also have Braille characters added beside corresponding letters, and the visually impaired child can listen to electronic speech and learn about words, sounds and spelling (*Figure 7.3.5.25.*). This may help the child who is learning to read and write and preparing for structured education, to keep up with the technological advances and use of software in PCs. Some software is also designed for use on computers for the blind and visually impaired. Such computers either have large print screens or Braille display screens on which the user can touch and read Braille output. Electronic learning aids may be considered a necessary toy as a learning apparatus for visually impaired children, as computers that they will use in the future will be a common medium with the persons with sight.

TOYS FOR BLIND AND VISUALLY IMPAIRED CHILDREN

The behaviour of play has been the main criterion through which the physical, cognitive and emotional development of the blind child has been encouraged and measured. Norris *et al.* (1957) used tests requiring play tasks to understand and assess the developmental stages of the blind children they observed. Fraiberg (1977) was one of the first to state that the lack of playful behaviour of blind children indicated their undeveloped ego. Nielsen (1991) developed a box of objects, The Little Room, in which the blind child could not help but come into contact with objects. In 1970, with his students, Papanek developed the Sensory Stimulation Wall which blind children could explore and manipulate. The examples remained as prototypes; though later, they have set examples for specialist toy companies (*Figure 7.3.5.26.*). In most nurseries which visually impaired children attend, teachers try to develop their own toys to stimulate the interest of children.

Figure 7.3.5.26. Tactile Wall and Interactive Tactile Wall by TFH.

Specialists in education of blind children and of blind people in general, have recently taken this important matter into their own hands, and have come up with several toys or equipment, to help fill in this enormous need. J. Dunnett-Roberts, a visiting teacher for the Suffolk County Council, has worked with blind and visually impaired children in both specialist and mainstream schools. During a day of visit with her, was observed a sensitively established child-teacher relationship that encouraged the children to interact with the external world, responding to interest, learning about the surroundings and taking steps to socialising. J. Dunnett-Roberts explained that, frustrated at the lack of good published material, with colleagues she made or adapted games, books and activities for blind children, though these material always had an air of 'home-madeness' about them. As she wanted children to have material that were functional but good looking as well, she designed some equipment to be produced by professional manufacturers. She has had The Little Room produced in the UK; her version is sold by the name BeActive Box, distributed by the RNIB. She has also designed the Jody Pegs, a set of pegs with knobs that fit into the holes of a board. The aim is to help fine motor control, and hand co-ordination, and it also is a game with rules that can be introduced to the child at a later stage.

Kinsley-Crisp, a low-vision consultant, has designed an 8-watt lamp for darkroom teachers. Recently he completed a Vision Assessment Kit, different from the ones used in clinics, which includes colour tests, and tests assessing residual vision. He believes that toys for blind and visually impaired infants should be functional to begin with, aiming at practicing physical skills, rehabilitating behaviour that needs to be corrected, and argues that toys should be clues to the surrounding world of the child rather than being friendly, cuddly items. He points out that most children with visual impairment will have additional disabilities as well, and so, a toy design that will suit all children with visual impairment is not realistic.

John Slade, a visually impaired designer, has developed the *Sladecolour System*. Having grown up as the only visually impaired member in his family, he felt he missed out on family activities and games that constituted an important part of family life. The games he missed out on, relied heavily on fine-motor (finger control) and visual (colour perception) skills. He explains that most visually impaired or totally blind persons would like to know about colours, and about how people with sight use them. He realised that colours can be used as codes in ordering certain functions, and believed this coding could be applied to the haptic sense, by representing each colour with a different formal detail. With his Sladecolour System, colour is conveyed by touch (*Figure 7.3.5.27.*). Tactile perception provided for the blind readers is generally in the form of embossed images. Slade has offered three-dimensional forms where the codes can actually be grasped or placed in the palm apart from being touched with the index finger. He has received support from the Birmingham University Research Center for the Education of the Visually Handicapped, in obtaining data on thresholds for tactile distinguishing. This information helped in determining the sizes of the shape codes; they had to be neither too small to be distinguishable, nor too big so as not to slow down the recognition process.

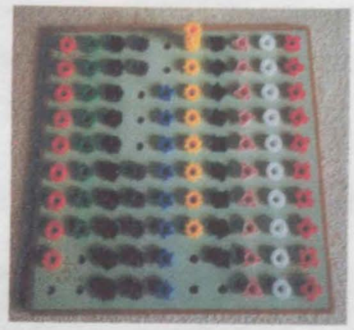


Figure 7.3.5.27. The Sladecolour pegs.

The shape codes were first developed to be used in board games, then they were developed into buttons to be used on clothing (*Figure 7.3.5.28.*). The colour codes on clothing are used to match the colours of clothes, or to sew on socks to identify pairs. While 10 colours are used for the board games, the buttons are made to represent 16 colours, with six extra fashionable colours such as turquoise. The colour codes for games are made as pegs that fit in holes on the board. This way, they do not fall off their places with accidental gestures, and they are picked up with three or four fingers, which immediately convey the shapes they are of. The starting point of colour-to-shape coding was circle for white, and square for black. Green followed with a three-petal shamrock reference, five-point star for blue, a cross for red with reference to the Red Cross, a sunflower for yellow, hexagon for brown with reference to nuts, and a triangle for pink. For combination colours such as grey, the colour-to-shape coding combines the shapes of black and white, resulting in a circle with four corners, a 'squarcle'. For turquoise, green and blue are combined to form a three-petal and three-point shape. These colour-to-shape codings are also

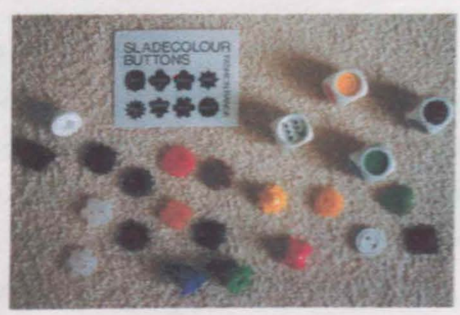


Figure 7.3.5.28. The Sladecolour buttons and dices.

used on the faces of dice that are used in the games. On the dice, petals are represented as embossed dots, the edges of the stars are represented with embossed lines, and the square and circle remain the same, but embossed on the surface (*Figure 7.3.5.29.*). Therefore, the three-dimensionality of the shapes is again represented three-dimensionally, but on 2-D surfaces. On the dice surface, the eight dots arranged in a circle represent the colour yellow, therefore the player knows he/she has to move the yellow peg. Again, the arranging of these codes required careful research into thresholds for distinguishing foreground-background relationships.

The board games, particularly 'Snakes and Ladders', also required research and thought into adapting them to the use of visually impaired players. This game relies highly on graphical layout, and so the adapted version conveys three-dimensionality through a 2-D surface. The game is solved by segmenting the actions involved. To convey the direction of the movements, tactile triangles are used; where the triangle points is in the direction of movement. The straight form of the tactile ladders points to the hole where the peg will be placed in, and the curvy form of the tactile snakes leads back to the hole that the peg falls back into. The tactile graphics are made of topple sand, ballatini, a specially manufactured material lacquered in a special way to bind together, a process discovered through trial. The games and colour conveying buttons are distributed by the RNIB and sell among the visually impaired population in the UK.

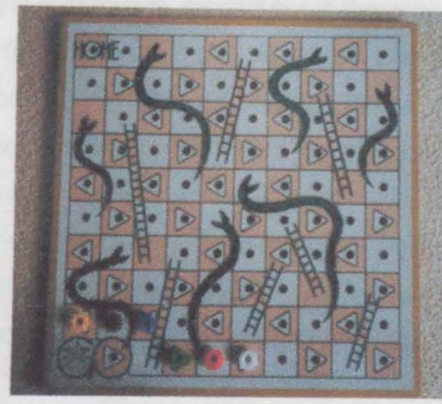


Figure 7.3.5.29. The Snakes and Ladders Board Game by John Slade.

DISCUSSION ON TOYS FOR CHILDREN WITH SPECIAL NEEDS

The review on toys for children with special needs available on the market reveals that, although from among them, there can be found examples that have stimulated children in severe physical and mental conditions, the needs and demands of particularly blind and visually impaired children are still not met fully. More effort should be devoted to introduce new concepts, search for new material uses, and technologies, in order to develop novel toys for this group of children.

The major reason why toy companies do not invest freely and do not produce toys in mass quantity for children with special needs, is their dissatisfaction with the number of potential consumers. The rare mass-produced toys are either of poor play value, or are offered as adaptations of toys designed and produced for children with no disability. The most common example are learning toys on which Braille characters are found. The easiest adaptations of toys on the market are made for children with visual impairment, and toys having a multitude of sound, light, movement effect, or those that have different materials or tactile quality are readily labelled as suitable for visually impaired children. Toys specifically designed for children with special needs can be found in smaller scale companies which have their products produced in workshops, and so are expensive, difficult to distribute or reach, difficult to have them repaired or maintained, and can have poor production quality and choice of materials. As the toys are not mass-produced, industrial moulds are not always prepared and plastic is not used for their production, which would have reduced their prices. The toys are generally of wood, plywood, or polyurethane foam covered in vinyl. This limits designs, makes the items heavy, and the designs require construction details that can easily wear out or be broken off by force. In general the designs are so specialist that they do not invite free play in other ways.

CONCLUSORY REMARKS ON TOYS FOR BLIND/VISUALLY IMPAIRED CHILDREN TOWARDS PROBLEM SPECIFICATION

The extensive review on the toy market, conducted parallel to the visits carried out to the schools and homes of visually impaired children, revealed that there is limited choice of toys and play material for children with sensory impairments. It was observed in the visits that the therapeutic or specialist toys such as activity puzzles were not played with at all, apart from those flickering or reflecting light and making sound, which were used only for their stimulating property. The amount of stimulation offered by the play value of toys was insufficient even for those children with additional severe learning difficulties, let alone visual impairment only. Exploring these toys and playing with them lasted only a short time as they did not offer a wide range of possibilities. The toys interacted with, were in general:

- used as a security object or transitional toy, always held by the child who refused to let go of it;
- used for repetitive play;
- used for stereotypical play for their stimulating property;
- used for exploring tactile and physical properties but not for the function or play activity offered.

Posting toys, through the slots of which objects disappear, were particularly made use of. The objects slid through the slots with sound, and fell into the boxes with clashes, which attracted the children. The adapted toys such as those with keyboards with Braille characters were not used, probably due to the following reasons:

- Some of the children were too young by physical or mental age to begin to learn the letters to read and write.
- Those at the stage of learning the letters were not in a physical condition to handle and to manipulate toys.
- The press-button speaking toys were only suitable for children with milder visual impairments.
- These toys had too many extra details the children could not make sense of, or did not find interesting to explore.

It is possible to say that, the nature of the play value offered by most of the available pre-school toys are not entirely suitable to the interests, abilities and needs of blind and visually impaired pre-school children. The incompatibility observed between the nature of presently available toys (particularly discovery and activity toys that address pre-school children and that give initial ideas on objects and their location in space), and the nature of visual impairment, may be related to:

- the degree of visual impairment of the child and the age of onset of the impairment;

- the physical limitations of the child;
- the cognitive limitations of the child;
- the child's willingness to explore and interact with the world; and
- the nature of the play activity that a given nursery toy requires.

The play value of a toy is largely related to the imaginative abilities of a child, and what creative approaches it invokes in the child. A child must be able to include in play, personal involvement and interest, otherwise a play activity may merely be limited to exercising a physical skill or self-stimulating behaviour. It has been observed during visits that the interactions of most of the children with toys has taken such an attitude, and constructive or functional play towards discovering properties of objects and their relation to each other within the surrounding world did not take place.

Toys for blind/visually impaired children should be able to offer flexible play possibilities, not limiting play into one or two basic tasks. The play value of such toys should add onto itself as the child develops and discovers further aspects about the toy, and about own abilities. The toy should not only address the inabilities of the child (such as blindness, therefore having mainly touchy-feely features for the use of the hands) but also the many different abilities that the child may have, which point out at the individualities of each child that may come across the toy. This conclusion also agrees with Kinsley-Crisp's argument that a toy design that will suit all children with visual impairments is not realistic. Such a design basically means the toy only addresses a singular inability: not being able to see. Another point that having to address the varying individualities of each child brings to mind is the importance of stressing flexibility of the toy or game by its involving a range of play possibilities.

Visual and audio stimulation may be a useful tool to primarily make the blind/visually impaired children aware of the play material's existence and to attract. Although visual and auditory stimulating properties may encourage self-stimulating behaviour, further properties of the toy may be used to adapt this behaviour into more functional ones, also giving the child a sense of cause-and-effect, autonomy, and accomplishment, and eventually of competence and self-esteem.

It has previously been discussed in *Research Topic IV* under *The Trends in the Toy Market Today*, that the latest trend in the toy market is to offer a background story related to a toy. Such an approach may also be used for children with visual impairment as it may encourage imaginative play, and make the children feel part of a group. Presenting a toy that may also be used within a play format may support the child in adapting into an imaginary context, and thus may help the child to systematically gain similar experiences through play, as peers with sight go through. Such a toy and play format may also encourage a peer with sight to participate in the play and provide a sense of sharing and co-operation for both parties, also helping them to know each other better and together prepare for future real-life situations.

OUTPUT: PROBLEM SPECIFICATION

7.4. ESTABLISHING DESIGN SPECIFICATIONS TOWARDS A PROGRAMME

INPUT: PROBLEM SPECIFICATION

To work out the criteria determining the properties and features for the toy to be designed, analyses are made, as to the toy types, the stimuli provided, and skills addressed by those toy types. *Table 7.4.1.* presents in the form of progressive stages, the skills that may be gained as responses to the stimuli. For example smell, as a source of stimuli, will *physically* instigate the child to use the sense of smelling. *Cognitively* this may help the child in determining locations or the function of the space he/she is situated in. *Emotionally* the child may develop different feelings about different smells by making associations (the kitchen: comfort, food, satisfaction; perfume: mother, security, affection, etc.). *Socially* the child will develop ideas on the social implications of the smell, such as the kitchen being a family reunion area, or, while eating one has to behave with table manners.*Tables 7.4.2.* present the investigation of how toys as sources of stimuli may affect these skills in the simplest sense. The toy categories used, can be found in *APPENDIX A.*

The use of the tables helped to summarise the possibilities that different toy categories offer, and how they can impact development. It can be said that, the more toys can be played with, and the more they are flexible as to how they can be played with, the more they are beneficial. It should be in mind that a child will choose with what aspect of the toy to play with, and how to play with it, depending on interests and abilities at the particular stage of development he/she is in, and on the limitations of the disability. *Table 7.4.1.* analysed the possible skills (physical, cognitive, socio-emotional) that the toy to be designed could help develop in the child with visual impairment. *Tables 7.4.2.* analysed how toys of various categories, as sources of stimuli, would give impetus to the mentioned skills. According to these analyses, the following toy types seem to offer the possibilities of experience, towards the cultivation of skills that would aid the development of the visually impaired child in diverse aspects:

Physical skills

- Discovery toys provide bodily contact with objects.
- Activity and learning toys allow active manipulation, both involving the use of the child's fingers and limbs for pure physical exercise, improving motor skills and co-ordination of body parts.

Cognitive skills

- Discovery toys allow discovering object properties.
- Activity toys allow discovering cause-and-effect relations.
- Learning toys give a basic understanding of objects, properties, concepts, etc.

Table 7.4.1. Table of Skills

STIMULATION ⇒	PHYSICAL SKILLS	COGNITIVE SKILLS	EMOTIONAL / SOCIAL SKILLS
SIGHT ⇒	Making use of residual vision	Basic knowledge of objects, environments, persons Contributes to object permanence Understanding of time (seeing clock face, observing the cycle of daylight-dark...)	Sense of happiness, fear, worry, in the sight of someone/something/ somewhere Leading to self-expression, seeking comfort ...
SOUND ⇒	Making use of hearing	Basic knowledge of objects, environments, persons Contributes to object permanence Understanding of time (to do something, to go somewhere, hearing the milk van in the morning, hearing a clock, an alarm, an announcement ...)	Sense of happiness, fear, worry, in the sound of someone/something/ somewhere Leading to self-expression, seeking comfort, vocal expression, use of language, interest in music, sense of rhythm ...
TOUCH-FEEL ⇒	Using hands and fingers for object contact	Basic knowledge of objects, environments, persons Contributes to object permanence Understanding of time (duration of a contact)	Sense of happiness, fear, worry, in the touch of someone/something/ somewhere Leading to self-expression, seeking comfort ...
KINAESTHESIA ⇒	Using hand and fingers for object manipulation Legs-feet for gait Trunk for posture Independent mobility Head/trunk-legs-feet for correct positioning of the body	Basic knowledge of objects, environments, persons Contributes to object permanence Understanding of time (duration of an activity)	Sense of happiness, fear, worry, while doing an activity Leading to self-expression, seeking comfort ...
SMELL ⇒	Making use of smelling	Determining functions of objects/materials (detergent, soap, washing liquid ...) Determining location (towards the kitchen ...) Determining the function of a space (the kitchen ...)	Social implications of different environments, such as behaving during eating, having table manners, etc. Emotional implications of different smells: pleasant, unpleasant ...
TASTE ⇒	Making use of taste Making use of mouth for articulation	Recognising objects/ materials from their taste Recognising what is edible and what is not	Evoking of feelings such as satisfaction of hunger, leading to happiness ... Emotional implications of different tastes: pleasant, unpleasant ...
		Symbolic representation	Self-representation, Self-expression
		Use of imagination	Self representation, enjoyment of individual fulfilment, self-expression, socialisation by joining in group play ...
		Creative problem-solving	Sense of individual achievement, contribution to a social situation ...

Tables 7.4.2. Toys as Sources of Stimuli Affecting Skills

SKILLS / **TOYS**	**Infant toys**		**Discovery toys**	**Activity toys**	**Learning toys (shapes, sorting, posting, scenery, etc)**
	Cot and playpen	**Rattles and teethers**			
Physical	√ Contact with objects	√ Manipulation of objects	√ Coming into bodily contact with objects	√ Active manipulation	√ Active manipulation
Cognitive/ intellectual	√ Understanding the existence of objects	√ Understanding bodily capabilities	√ Discovering properties of objects	√ Discovering action-reaction	√ Gaining basic knowledge and notions
Social			√ Adults may be involved	√ Adults may be involved	√ Interaction with adults
Emotional	√ Comfort seeking	√ Comfort seeking, attachment	√ Self-satisfaction	√ Pleasure, motivation into acting further	√ Interest and willingness to learn, motivation

SKILLS / **TOYS**	**Dolls**		**Plush**	**Pretend play**		
	Fabric/plastic Dolls, babies	**Fashion dolls, action figures**		**Costumes**	**Props**	**Scenery toys**
Physical	√ Manipulation of toy	√ Manipulation of toy	√ Manipulation of toy	√ Dressing up	√ Moving around, manipulating	√ Manipulation of toy
Cognitive / intellectual	√ Learning about body parts, dressing, feeding, taking care of	√ Notions of fashion, life-style, jobs		√ Learning about	√ Learning about	√ Learning about
Social	√ Imitation of social roles	√ Playing socially, being part of a group that owns an item	√ Giving or receiving as gifts, won as prizes	√ Playing together	√ Playing together	√ Playing together
Emotional	√ Comfort seeking, attachment	√ Imagination, self-representation	√ Personification, comfort-seeking, attachment	√ Imagination, self-expression	√ Imagination	√ Imagination

TOYS / SKILLS	Ride-on toys: Rocking toys	Ride-on toys: Pedalling toys	Vehicles: Manually moved	Vehicles: Radio controlled	Construction sets: Large pieces	Construction sets: Small pieces	Games and puzzles
Physical	√ Gross-motor control, using strength and balance	√ Gross-motor control, bodily co-ordination	√ Manipulation of toy	√ Eye-hand co-ordination	√ Gross-motor control, physical activity	√ Fine-motor control	√ Manipulation of pieces, fine-motor control, eye-hand co-ordination
Cognitive/ intellectual		√ Learning about effort and speed, steering, direction	√ Learning about different vehicles	√ Speed, direction	√ Size, space, weight, constructing techniques	√ Creative problem-solving by putting pieces together	√ Logical approaches and creative thinking towards problem-solving
Social		√ Moving within social environment		√ Can be part of social play, racing, competition	√ Can be social play, co-operation, building together	√ Can be social play	
Emotional	√ Pleasure from bodily sensations	√ Enjoyment, pleasure		√ Excitement	√ Creativity	√ Creativity	√ Patience, overcoming frustration

TOYS / SKILLS	Games with rules: Card and board games	Indoor and outdoor activity: Sand and water play	Indoor and outdoor activity: Playground equipment	Indoor and outdoor activity: Games for bodily activities	ELAs	Video games	Smart toys
Physical	√ Manipulation of pieces, fine-motor control	√ Bodily stimulation	√ Gross-motor control, activity	√ Gross-motor control, physical co-ordination	√ Eye-hand co-ordination	√ Eye-hand co-ordination	√ Manipulation of toy, ...
Cognitive/ intellectual	√ Sequential thinking, strategy planning	√ Learning about volume, density, fluidity	√ Learning about structures, outdoor, weather conditions	√ Learning about the body and its physical capabilities	√ Learning about notions, basic knowledge of things	√ Logical thinking, problem-solving, learning from experience	√ Logical thinking, interactivity
Social	√ Playing with rules, turn taking, co-operation	√ Can be social environment	√ Turn-taking	√ Turn-taking	√ Interaction with peers, with teacher		√ Social status
Emotional	√ Patience, overcoming frustration, excitement	√ Pleasure, relaxation	√ Pleasure, stress release	√ Pleasure, stress release		√ Excitement, frustration, sense of achievement	√ Sense of control, sense of responsibility, pleasure

Social skills

- Discovery and activity toys may involve the presence of adults and sighted peers.
- Learning toys would be a means of interaction with adults or sighted older children who would help teach, thus extending the social circle.

Emotional skills

- Discovery toys when well played with, would give a sense of self-satisfaction and confidence to the child.
- Activity toys would bring pleasure and a sense of accomplishment, and would motivate the child further.
- Learning toys, once the child is involved and engaged with the learning process, would motivate interest for further knowledge.

DETERMINATION OF THE DESIGN ASPECTS

These categories of toys, enriched with the involvement of social play and rules, and inspiring imagination, would be appropriate for visually impaired children of pre-school age, as agents for developing their skills towards a well-balanced way of life, through the experiences they would provide. The review and analysis reveal that there are no toy categories that provide all these experiences at the same time. An interactive toy has to be designed and made to involve the properties of discovery, activity, learning, imaginative play, social play and play with rules. To initiate an act from the blind child's part, the toy should be an interactive one, responding in many ways to even an accidental contact made by the child. An immediate response to any gesture will make the child aware of the toy's presence, and of its nature as the child deals with it further. Also, when the environment joins in this interaction between the child and the stimuli-producing toy, the toy gains further meaning defined by a new dimension *-the dimension of space-* in achieving its purpose. Apart from the toy that acts as the mediator, the environment in which the child and the toy are situated can also be a contributing factor in the processing of information gained through the child-toy relationship. The design of a toy and its relationship with the surrounding environment is actually designing an experience in physical, intellectual and emotional terms for the blind child. The co-operation of the child-toy-environment (c-t-e) integrates in this relationship different tasks, which the child interprets according to his *intellectual capabilities* and (re)acts upon, according to his/her *physical condition*. Given that what blind children miss is experience in all aspects of life when compared to their sighted peers, this c-t-e relationship can prove to be useful if arranged in a harmonious and effective way. In this relationship is also involved the *complexity* factor, that evokes interest and demands participation from the child, and puts the child in certain situations or tasks that he/she will have to overcome, complete, and enjoy (problem-solving). The different levels of difficulty within this arrangement may reveal themselves according to the expectations and capabilities of the child.

As a result, the ideal toy should be: interactive within its medium, and with the approaches of the child. The toy should be able to represent to the blind child the 'world' not perceived with the eyes, on a scale understandable and easy to cope with, both in size and in concept. It is apparent that such a toy should involve the use of diverse media and diverse stimulating features and effects. The toy to be designed for the final project should be interesting and stimulating all senses as much as possible, yet not too overwhelming and unclear. The toy should:

- demand simple tasks the completion of which gives the child a sense of accomplishment;
- be flexible as to the way in which it is played with;
- be added with more complex functions as the child gains experience;
- make the child exercise a skill without feeling pressurised.

As a toy is an object acting as the medium of providing these experiences, it should:

- encourage active physical involvement of the child; this can be through having many different parts to be explored and manipulated;
- have clear and distinct features also leading to an idea of the whole;
- have intellectually stimulating aspects to its physical appearance and concept; be a source of information and exploration about the objects and events in the environment during play or during rest;
- be enjoyable and user-friendly to the child. This enjoyment and user-friendliness can be provided through easy-to-understand features, parts pleasurable to explore, by making the toy safe, and with features that will emotionally attach the child to the toy to seek comfort from, when people are not available to give this comfort.

REQUIREMENTS FROM THE PRODUCT VERSUS CAPABILITIES OF THE USER GROUP

Suitability to the Physical Abilities of the Children

There will be children who may not be physically competent, with limited gross-motor and fine-motor control; they may be unable to respond or react quickly to certain details of and actions from the toy, and to perform all the tasks that the play material requires. Therefore the details of the features must be designed accordingly: not demanding too refined and controlled physical actions, or if they do, suggesting alternative ways of carrying out the same activities. Although the toy will be designed to be suitable for pre-school age, it must be expected that children under 3, or children over 6, may also come across and play with the toy. This points at the importance of toy safety: sturdiness to carry weight, strength against applied force, materials used, small components, loose strings, protrusions, or sharp edges, etc. The design must therefore consider safety regulations as it is a product to be played with by children with visual impairments, some of whom will have no sight at all to perceive what they are dealing with.

Cultivation of the Cognitive Abilities of the Children

The play material must offer diverse play experience for children with differing cognitive skills at differing mental stages. Therefore the toy must not be difficult and frustrating, neither must it be too simple and limited as to the possibilities it offers. This may suggest that the toy involve different aspects and tasks addressing a gradation of stages of complexity to be able to serve children of varying capabilities.

Input from Piaget

Inspired by Piaget's theories on sensori-motor development and the pre-operational stage, the toy must reflect the sequential development of

- the sense of self (ego development),
- objects concept (object permanence), and
- spatial concepts

in the levels of complexity that it offers. Therefore the final toy is to be a system of play material which is large enough to convey basic *spatial concepts* to the child as well (such as what an enclosed space is consisted of: walls, floor, ceiling, openings, etc.). The components of this system should be able to make the child aware of their existence and location through the stimuli they offer (*sense of self* and *the other* for ego development). The play material within this system must be composed of objects that the child can find, manipulate, and relocate at other times as well. The child must understand that these objects continue to exist in this system and can be found again even if they are not where the child last left them (*object permanence*). This property brings to mind, another source of inspiration to the project concept: Montessori's classroom setting.

Input from Montessori

Montessori suggested that each material in the classroom setting had a place, and everything was to be found in its place when not in use. The children in the setting could play with what they wanted, but they had to take them out themselves, and place them back in their location. The classroom was made suitable to their measures, and the play activities all had their specific purposes and benefits. The system then, can be composed of diverse pre-school activities, and each activity or object related to the activity can be located in their own spaces, at locations easily accessible to the child.

Educational Play Activities to be Fulfilled

As the toy is designed to have educational aspects, the pre-school activities of the children must be taken into account. The play material may offer activities such as

- counting,
- grouping,
- matching,
- ordering,
- completing,
- placing and displacing,

to understand notions such as property, amount, belongingness, etc. With interactions with the teacher or adults, the child may also learn about the properties of objects, of the world, of time, seasons, nature, etc., through the activities. To offer a basic understanding of the world is an objective of the play material. Further, the system may invite physical activities such as

- running,
- climbing on and off,

- getting over,
- walking around,
- crawling under or through, etc.

Another objective of the play material is to offer a boundary within which the child will feel secure to physically act freely. The play material may also be part of a story setting as suggested earlier, with its own characters and adventures. This may offer the child the possibility of being part of the story with using self-representation skills, of contributing to it through imaginative and creative skills, and to role play in co-operation with the teacher, adults or other children, sighted or blind. Another objective is therefore to make the play material a means for social interaction between the children and their peers, blind or sighted. Thus the children can feel that they share the same experiences and are part of the same world.

Physical Properties Broadly Defined

The project will be a system of play material that offers diverse cognitive, physical and imaginative activities that may be played alone, with an adult or with peers.

- This system must be able to be built within an indoor environment such as a playroom.
- The play material must offer the maximum amount of safety in case the children are left in the room without supervision.
- The play material must be all relatable to each other, forming a whole that will be easy for the child to understand.
- The play material must offer diverse stimuli that the child can make sense of, and the sources of which the child can locate. These stimuli may be in the form of light, sound, vibration, different textures and materials, smells, change of air flow, etc.
- The play material must also make sense and be functionable when they are taken away to be played individually.
- The system may be constructed of diverse materials giving different forms, textures, feelings, affecting different senses at the same time.

LIMITATIONS

The research and project also has limitations due to time and economic factors involved. The project is part of a PhD research. This gives flexibility on the time involved, particularly in the devoting of extensive time on the research carried out, and the acquiring of the outcome. As the work is undertaken individually and not as a teamwork, a longer time is indeed a necessity. Some economic and technical restrictions are expected, as the project is carried out and manufactured within college facilities.

OUTPUT: THE DESIGN SPECIFICATIONS

7.5. CREATION OF THE CONCEPT

INPUT: DESIGN SPECIFICATIONS

Once the design specifications are determined as to the physical properties and meaning producing qualities of the toy system, the phase of searching for concepts may begin.

GENERATING IDEAS FOR INITIATING MOVEMENT OF THE BODY IN DISCOVERY OF OBJECTS

Scenario 1: The blind child is in a period of inactivity, either resting or waiting for something to happen. A sound begins, in the form of a melody that attracts the child's attention. He/she is able to locate the side the sound comes from, and is in an attentive mode, waiting to feel the physical/sensual effects of the action that is causing the sound.

Idea 1.a (Figure 7.5.1.): The infant is not an active one, and does not initiate bodily movements on his/her own. The infant moves limbs instinctively in lying or prone position. With each moving limb and accidental encounter of the limbs with objects, there is the production of a different sound. The intensity of the sounds depends on the force with which the child uses the limbs. The most basic way to do this is attaching bells on the ankles and wrists of the infant, or hanging sound producing mobiles over the infant.

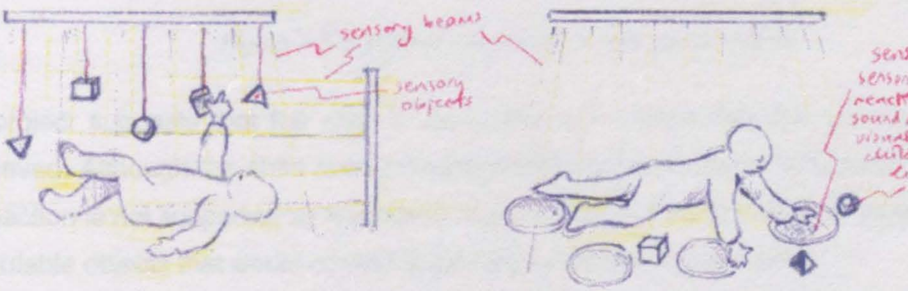


Figure 7.5.1. Sketch idea for movements resulting in sound.

Idea 1.b (Figure 7.5.2.) : The child has pulled him/herself to a sitting position, can track sounds and extend arms towards sources of sounds. This concept involves interactive stimuli from the proposed system, the existence and variation of the type and intensity of which, depends on the child's conscious and accidental movements. This interactivity between the stimuli, the child and the defined space, contribute in the formation of a 'discovery and activity play system'. In this system the object is in the form of beams and the resulting sound, and the child is using close space.

- With each accidental gesture, the child hears the amplified sounds of contact with the beams coming out of panels placed around.
- The child gets familiar with the specific sounds accompanying each movement and understands that they are a reaction to each action.
- The sounds are now heard from a distance no longer within the immediate reach of the child (the beams are shortened so the child cannot activate them with gestures from where he/she is positioned).
- The child locates these distant sounds and attempts at moving body towards the direction they come from.

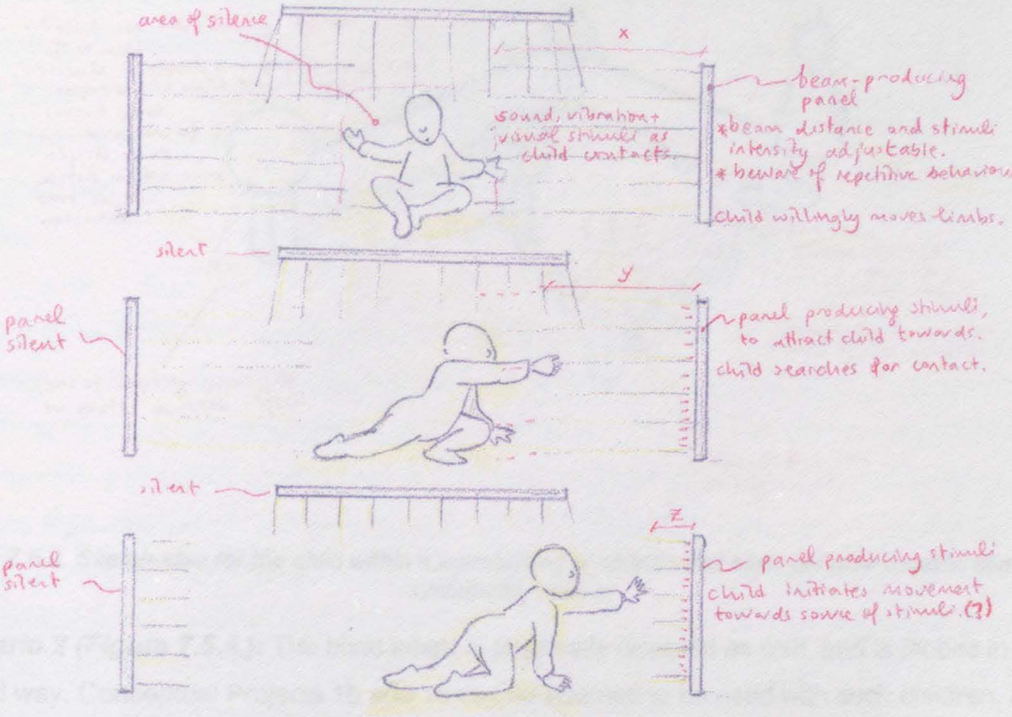


Figure 7.5.2. Sketch idea for panel with sound beams.

This project suggests that the child is stimulated with beams that are actually not haptically perceieved. Although the child may understand that sound results as a reaction to movements, this reaction is not supported by feelings of touch. It might be a better idea to replace beams with manipulable objects that would convey haptic and kinaesthetic information.

Idea 1.c (Figure 7.5.3.): The child is on his/her feet, and mobile, but feels insecure in taking steps and confronting objects on the way.

- Each step of the child and movement of each limb is accompanied with a sound or another stimuli that is known to encourage the child.
- Familiar or novel toys/objects are placed in a systematic manner in the child's surrounding, and each object makes the child aware of itself with a specific stimuli as the child approaches them.
- The child is interested in this activity, and feels encouraged to take further steps towards the objects. He/she gets used to the idea that there are no obstacles between him/her and the specific sources of stimuli.

The final stage of the project suggests that the child's movements result in a reaction from the system, but this time the child's activity is towards an attainable goal that is preceived by other means as well as by sound. The child also learns to concentrate and make sense of audible information from the environment towards wayfinding and locating an object.

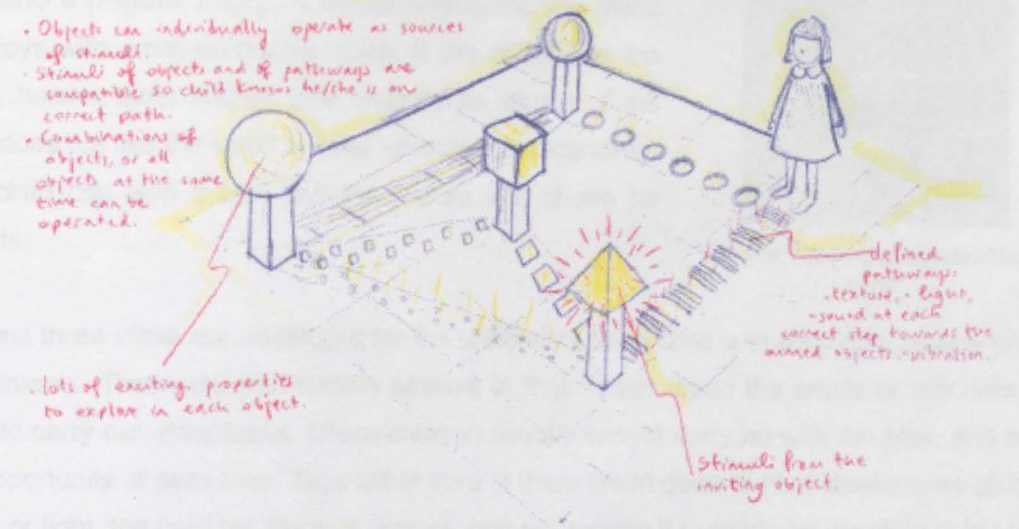


Figure 7.5.3. Sketch-idea for the child within a surrounding of objects that send out their specific stimuli in a systematic manner.

Scenario 2 (Figure 7.5.4.): The blind infant is physically disabled as well, and is mobile in a very limited way. Conceptual Projects 1b and 1c can be adapted to be used with such children, also in wheelchair. Or else, the child has access to objects placed immediately around, which have numerous stimuli to offer as reactions to the child's movements. A one-to-one relationship is encouraged between the child and the toy-object. As the child has movement difficulties, poor control of hand and no use of fingers, this relationship has to be initiated in a simple way. With accidental gestures of the fist, hand or head, the toy produces stimuli. Accidental gestures in time give way to more controlled voluntary movements.

Figure 7.5.4. Models for easily operatable touchy-feely objects with many stimuli.

Scenario 3 (Figure 7.5.5.): The child has additional learning difficulties and is in general inactive in the area he/she is placed. During these periods of inactivity, feely compositions of objects are placed by the child, on which he/she can rest arms and hands. The different textures and forms of each individual toy-object will leave a different sensual impression on the child.

Figure 7.5.5. Models for small objects with different feels.

Scenario 4 (Figure 7.5.6.): A similar arrangement is made with toys with smell-producing spice. If the child likes the smell, he/she turns his/her face towards its source. If the child does not like the smell, he/she turns his/her face away. The child can also grasp, feel the texture and shake for sounds.

Figure 7.5.6. Shakers emitting smell.

The last three ideas are developed for the understimulated child with additional severe physical impairments. These children remain passive in their chairs when the adults or teachers leave them to carry out other tasks. These children usually cannot carry on with the play, and so lack the opportunity of pass-time. Toys left in front of them are in general hard plastic ones giving out music or light, too hard for physical contact, and not making it possible for the child to lay his/her head in front if they are placed on the chair's front tray. The ideas described were thought as alternative playful material that are soft and each object has its own additional interesting property (such as vibration, light, sound or smell) and the child with learning and communication difficulties may in time learn to connect these properties with the stimuli in order to recognise an object and show preferences. These stimuli may also allow the child to vary his/her positions in the seat (such as turning head towards or away, moving arms, etc.).

These initial ideas were thus towards initiating bodily movements in an attempt to discover objects and their properties, and to act upon these objects. The main objective of the final toy to be designed, is to make it a learning toy. It should offer play value that addresses the problem areas described in the preceding sections, such as learning about the body, the objects and the world in general, so some ideas tried here may come to use eventually; but the toy should also offer the child tasks towards carrying out certain pre-school activities appropriate to the blind child's range of accomplishment at that stage.

GENERATING IDEAS FOR LEARNING TOYS THAT INVOLVE THE TEACHER IN THE INTERACTION BETWEEN THE CHILD AND OBJECTS

The presence of an adult will speed up certain experiences and may add more to what the child gains from them. The following group of ideas are developed with the aim of involving the contribution and interaction of the teacher, while the child is provided with the learning experiences.

Scenario 5 (Figure 7.5.7.): The blind child makes use of hands and fingers, and is ready for more structured and complex exploration.

Idea 5.a: Cubes with different fabric textures are presented to the child. The child explores their qualities, habituates his/her fingers to different feelings in a single graspable size object. The child also learns the properties

Figure 7.5.7. Model for the soft fabric cube

of a cube, six faces, eight corners and twelve edges. The reason a cube is chosen is the textural possibilities that different surfaces offer, and also the cube being a form easy to understand, to place on a surface and to pick up.

Idea 5.b (Figure 7.5.8.): The child is reluctant to touch soft objects. A cube is prepared that has two hard surfaces, two soft surfaces and two combination surfaces of hard and soft materials. While exploring the hard surfaces and the hard tactile details on these surfaces, the child comes across softer material. The child understands that there also are limits to softness, and soft objects do not change formal property. The child is interested in the tactile qualities and compositions, and hopefully in time gets used to handling soft objects. The cube describes gradual change in the properties of hardness and softness.

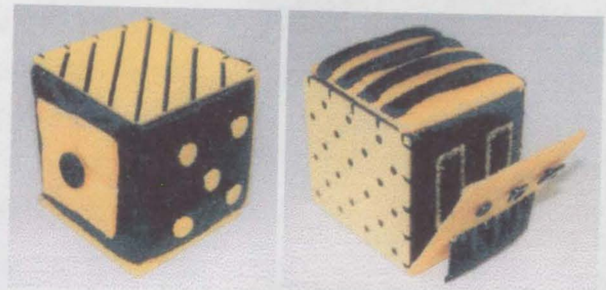


Figure 7.5.8 Model for the cube with soft and hard surfaces with features to explore.

Idea 5.c (Figure 7.5.9.): The child is presented with four identical cubes in a frame each with different six surfaces, and is expected to find and replace in the frame the cubes according to matching surfaces.

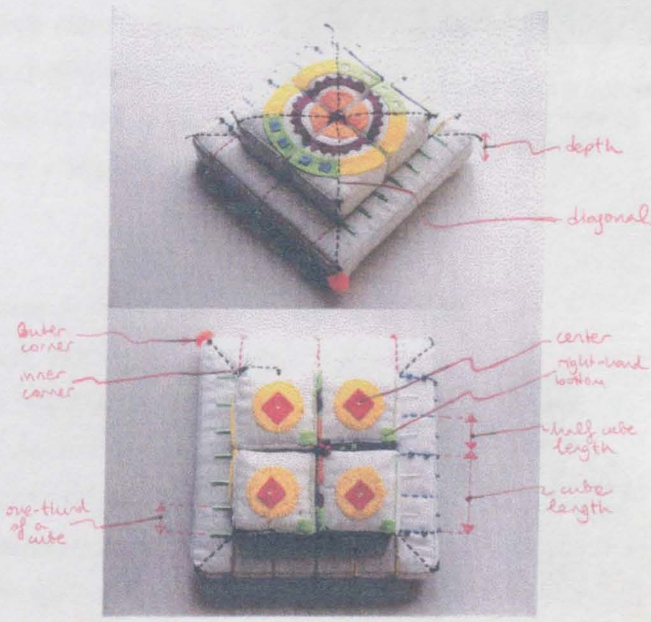


Figure 7.5.9. Model for the fabric puzzle cubes.

The toy contains details teaching the child to approach the task in a systematic manner; the edges and corners are defined individually to give the child indication marks as to which surface is already explored. The frame is also detailed with indications, helping the child to understand basic measurements.

Idea 5.d (Figure 7.5.10.): The child is presented with a puzzle of cubes to rearrange according to the matching surfaces, and then to the tactile patterns they form as a whole. The toy defines two stages:

- Recognition of similar texture.
- Re-arranging the pattern defined on the surfaces.

Idea 5 is a search on the gradual development of an understanding of parts towards the whole. A simple cube with different textures on each surface is for discovering the properties of a cube. The next step offered is discovering new details on a familiar object, thus relating surfaces to each other (neighbour surfaces) and making use of these details in finding new uses to this object (pulling, twisting, picking, combing, feeling, etc.). The next steps suggest that although it has individual properties, a cube can be related to others to become part of a whole. This whole may represent a group of objects that have similar properties, or it may involve objects with patterns that only make sense when they are arranged in the correct way. The objects involved become more complicated and more refined to explore. Feeling and manipulating are no longer enough, but more complex thinking is involved, such as making use of different details as different sources of information about the object, identifying, sorting and matching patterns, and putting the cubes in order.

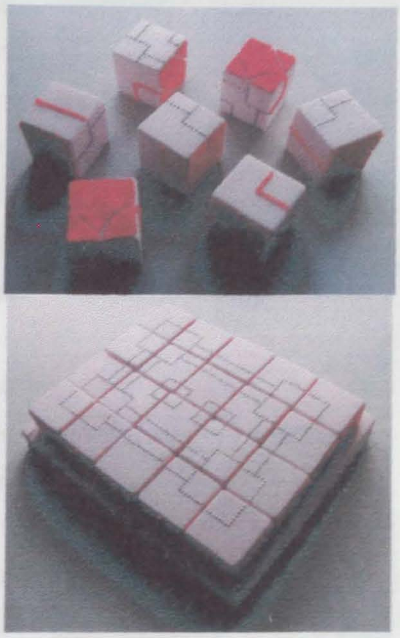


Figure 7.5.10. Model for the puzzle cubes with the surfaces forming different tactile patterns.

Scenario 6 (Figure 7.5.11.): The child is to be introduced to the notion of scale.

Idea 6.a: The child is introduced with two flower shape objects; one at a size graspable and explorable with two hands, the other smaller to fit in one hand. The child gets familiar with the consistent repetition of five petals on the big one, and also with the cut out hole of five-petal flower shape in the center. Fingers are used to explore the curves and the looped pattern. The child is explained that the small flower fits in the center of the bigger flower, and continues exploring to get familiar with the cut-out and the hole it belongs to.

Figure 7.5.11. The simple flower puzzle with one small central flower.

Idea 6.b (Figure 7.5.12.): The child is presented with the larger flower of five petals, to explore with the use of both hands and fingers. The child learns that, the flower he/she is already familiar with, fits in the center of the largest. Each petal contains a mini-flower to take out and fit in. With the use of contrasting colours and material, the child distinguishes the central mini flower from the others. The child also understands that these are all in the same shape, in proportion to each other. They are in different sizes (small, bigger, biggest). This is an introduction to the notions of size, order and scale.

Figure 7.5.12. The larger flower puzzle with five petals and five small flowers that fit.

Idea 6.c (Figure 7.5.13.): The child is presented with the mid-size flower with the mini flower in the center. The child exercises simple displacing–replacing activity, and understands they are the same shape in different scale due to their repetitive and symmetrical nature. Then the child is introduced to counting the raised dots on the petal of the mid-size flower. When returned to the petal with one single dot, the child knows the petals all have been counted. The child learns to count up to five.

Figure 7.5.13. The flower puzzle with raised dots and central flower.

Idea 6.d (Figure 7.5.14.): The activity becomes more complex with the introduction of the largest flower into which the mid-size flower fits. This time, the mid-size flower fits in one way only, although the shapes are symmetrical. The child has to bring together the single dot on the mid-size flower with the single dot by the edge of the inner hole on the large flower. Also, the mini flower on each petal this time fits only when aligned with the matching raised shapes. So, the child has to first find the petal with the matching raised shape, and then to insert the mini flower in the petal by aligning it with the one on itself. This level of complexity adds upon the task required from the child, and contributes to cognitive and fine-motor development, but the main reason is to provide further conversation and interaction possibilities to the child and the teacher.

Figure 7.5.14. The complex flower puzzle with raised dots and shapes to match the small

Scenario 7: This idea is developed to introduce to the child with learning difficulties or the blind child with difficulties in manipulation, basic forms in 3-D (sphere, square prism, triangle prism) and their representation in 2-D (circle, square, triangle). The shapes defined by the frames are emphasized with raised white lines. On each corner is a raised dot indicating the angled turn into another edge. One of the dots is larger than the rest to act as a reference point to stop counting for further corners and edges. The forms and frames are of bright colours as a source of visual stimulation and are filled with beans, rice and a bell to produce sound, when they are moved.

Idea 7.a (Figure 7.5.15.): On three white cards are placed the forms in frames, and above them are the white cards on which the shapes are defined in raised black lines. The child is asked

- to explore the forms, the frames the forms are in, the shapes defined by black lines;
- to pick the forms and place them centered within the black lines on the card they belong to;
- to pick them from the cards and place them back in their frames;

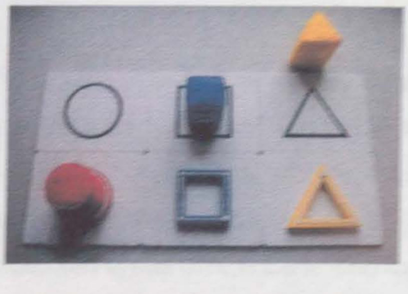


Figure 7.5.15. The cards and forms placed easy to relate.

• to thus relate the forms, the frames and the black-line shapes.

Idea 7.b (Figure 7.5.16.): This time the cards are mixed. The child is now expected not only to move forward and displace objects in a perpendicular axis, but to search for the matching forms and cards in diagonal movements as well.

Figure 7.5.16. The cards and forms placed in a mixed layout.

Idea 7 is developed as an introductory toy for basic maths. The child learns to count edges and corners of shapes in 2-D, and comes to recognise the projections of these shapes in 3-D. Each form has material in it that makes sound when shaken. As the child shakes the forms for sound, he/she may also develop an idea of weight. If the child has difficulties in grasping, picking up and placing accurately, the tasks involved in the game offer the opportunity to practice these skills. The black raised lines are used to provide contrast for the child who has residual vision. They are left larger than the forms so that the child with difficulties in using the hand, has plenty of space to place the form he/she is carrying. The frames may be considered as a second stage for when the child has better control of the hands.

Scenario 8 (Figure 7.5.17.): The child is cognitively ready to match, group and count objects. This idea is developed from Idea 3, where compositions of colourful objects were used. With this idea, each number is represented by different groups of objects, with distinctive bright colours and characteristic features. There are cards up to the number 10. The objects are magnetic and catch the cards easily. On each card the target area is defined with a circle; the number is represented in print characters and in Braille characters on two corners of the card. The amount that the number indicates is also represented as marks on the circle. The toy also aims at encouraging the child to use finger grip, and to control the wrist and arm movement. The varying details of each group of objects are sources of conversation between the child and the teacher.

Figure 7.5.17. Counting cards and objects.

With the diverse forms, details and colours, *Idea 9* aims at making the activity it demands, *more fun*. The child uses hands to go through a composition of small soft objects. Apart from putting hands on a feely texture of stimulating nature, the child can pick up objects, identify their properties and make own compositions. The child learns to match and group objects. The child also practices accurate placing of the small objects within the defined areas on the card. The toy is also a search through how a single material can be used and arranged to convey different properties.

Scenario 9 (Figure 7.5.18.): The child has poor control of wrist, and has to be encouraged to make more use of the hands and fingers. The project is a set of learning toys with: a magnetic collecting form, a velcro collecting form, a cylindrical container filled with small magnetic and velcro items, and a soft board onto which the items are placed.

- The child uses the forms holding them from the red knobs to plunge into the container and make stirring movements. *Holding the forms: Grasping the knob and carrying the weight to exercise hand control. Stirring movements: Strengthening and learning to control the wrist.*
- The velcro or the magnet items stick onto the forms, depending on which one is used. The child takes out the form and places it firmly on the work surface. *Holding the form down firmly: Hand and wrist control and strengthening.*
- With the fingers of the other hand the child picks the items stuck on the surface of the form, and places them on the soft board. *Use of fingers: Strengthening of pincer grip, fine motor control.*
- The identical items are grouped according to their physical properties.
- The child and the teacher discuss these properties, and try to find further identical items until the container is empty.
- Then the child picks the items up from the board, fills them into the container, and helps in putting the rest of the tools away into the packaging. *Packing away: Completion of a task, and assuming responsibility for putting away the play set.*

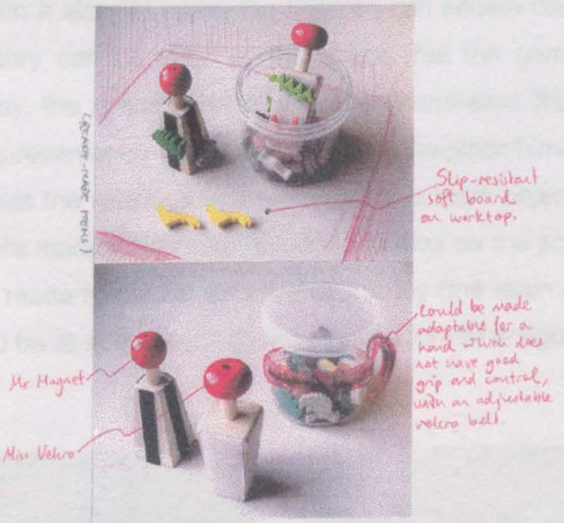


Figure 7.5.18. The forms to grasp and stir in the bucket of objects.

ESTABLISHING THE FINAL CONCEPT

The ideas discussed above are one-off solutions to particular problems some of the children may have, such as concentrating on a task, grasping and manipulating objects, discovering their properties and placing them within the required area. Although they involve diverse skills towards carrying out different tasks, it may be argued whether these ideas are individual solutions to individual problems and if they mainly address the common inability of sightlessness, and neglect addressing latent abilities that could be brought out. As learning toys, these ideas offer different tasks towards acquiring different skills, which may preferably be supported with the interaction of an adult. They involve details as clues, as signs of a different language that will offer information to the visually impaired child who may otherwise take longer to discover it by him/herself.

The initial ideas offer single tasks or play possibilities, and these tasks keep the child static in front of a table-top. Could the toy to be designed demand use of more space? Another matter is that the alternative material proposed were better to the touch than is commonly found in the market, but brought considerations of safety (as most toys involve small features that can be pulled off and swallowed), durability, or difficulty to maintain hygiene. On the other hand, combination of various materials (such as hard and soft materials) used on the toys brought novelty comparing to toys found in the market.

This stage of *developing ideas and establishing the final concept* has required an *iterative process of evaluation, re-evaluation and reconsideration* of the ideas, in relation to *the problem definition* and *design specifications*, over an over. Reviewing the design specifications, the main objective for the project can be redefined as: *offering blind/visually impaired children play value that they can benefit from at different stages of their development and addressing the different abilities each individual child may have.* Therefore, the toy may invite numerous activities, preferably keeping the child spatially occupied as well, as much as the physical capabilities may allow. If movement in space is difficult, the toy should perhaps be one on which the children can invent a story, or one with a story in which the children can situate themselves; making the toy part of a game. The story can be used as the *space* that the game occupies, and be the framework for how the toy, the space and the child are interrelated, thus helping the child, who has limited use of self-representation and imaginative skills to place him/herself within the context of the story. To investigate the relations between a child, a main object (the toy) and a defined space, rough models were made which also helped to decide on the scale of the project (*Figure 7.5.19.*) Sketches were made to decide on whether the toy (the main attraction for the child in the defined space) would be abstract (such as shapes and forms) or figurative (such as a toy with a face) (*Figure 7.5.20.*).

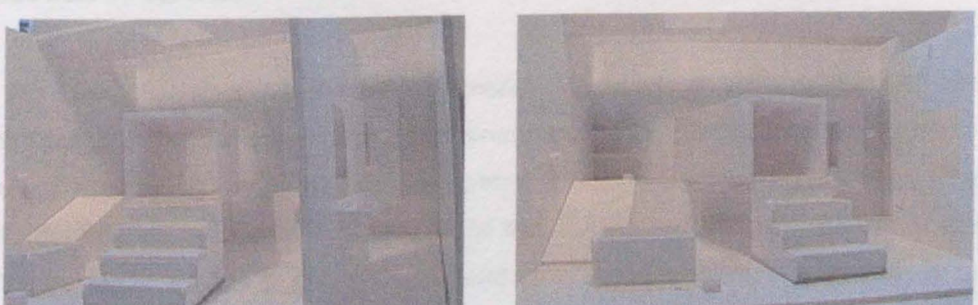


Figure 7.5.19. Studies of elements found within a built environment.

The final decision rested on the toy being an abstracted dog, placed within an environment, an enclosure with boundaries within which the child would feel safe to be mobile. The environment would contain certain objects dispersed within it, and these objects could be part of the dog when placed on its body. These objects would also require certain play activities. Some of the activities related to the objects could be incorporated from earlier toy designs made during searching for ideas towards a concept, that have been already described.

Figure 7.5.20. Preliminary sketches for a sit-on toy.

Once familiar with the enclosure through exploring, the child may also learn the locations of these objects and the dog. Exploration of a space with many elements in different locations and making sense of the whole, may be a long process. Before the child loses interest in such a process of discovery, the objects within this space should rather make aware of their existence, by sending out stimuli in the form of light, sound, vibration, etc. After understanding that these stimuli have sources which are objects that exist, following the clues, the child may locate them to be able to play with them at later stages. Based on this principle, it is suggested that this environment be interactive with movements from the child. Thus, the environment can play games with the child, with the use of the objects and the dog placed in the center, as the tools.

The aim of the project is thus to provide the means for a blind/visually impaired young child to develop sensitivity to environmental conditions and to the ongoing events in the '*world out there*', in the meantime offering activity possibilities that contribute to the development of physical, cognitive and emotional skills. This space will offer different levels of experiencing space–object relationships, beginning with coincidental and random encounters, and then giving way to more conscious acts by the child.

Within this interactive spatial system, the elements individually or in interaction with each other, will contribute to the ongoing events and environmental circumstances. The environment consists of modular units that can be arranged so as to form openings, enclosures, platforms. The objects within its boundaries are forms similar to those that the young child can encounter within daily surroundings while exploring the world beyond close space. When the system is on, these objects send out stimuli to inform of their existence and location within this space. Depending on the level of the game, this may be one object at a time, two objects at a time, or more. As the child encounters them in an explorative journey in this space and comes into contact with them, the stimuli from the encountered and explored objects end. To give more meaning to the existence of these objects, with the presence of Zog, the abstract dog, and the Interactive Stool presented in the following section, a game may be made up and defined for the children.

DESCRIPTION OF THE FINAL CONCEPT: AN INTERACTIVE PLAY ENVIRONMENT

Objects

These are basic forms (such as cubes and spheres easily recognised and named by very young children), complex forms (such as stars and flowers), the letters of the alphabet and the numbers (*Figure 7.5.21.*), some of which may be incorporated from the ideas described earlier. The objects come in different sizes, weights, degrees of softness or hardness. This gives the child the opportunity to handle them with fingers, with one hand, and with both hands depending on their size and weight. The child may also consider each object as an individual toy to explore and manipulate. Or else, each group of objects may be a matching, sorting and counting toy to be played with.

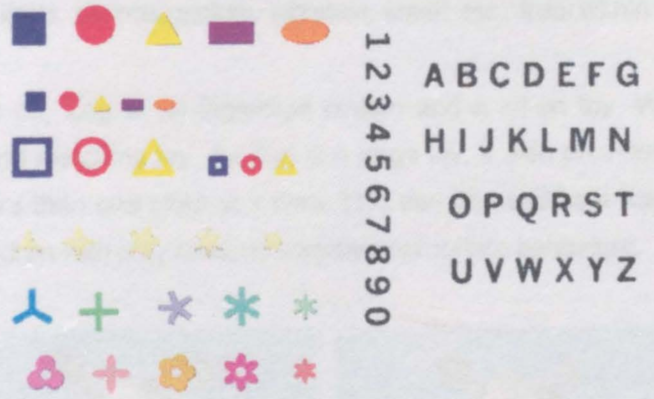


Figure 7.5.21. The objects and letters.

Objects and the Stool

The stool is interactive with the spatial system that includes the objects, and is designed as a posting toy (Figure 7.5.22.). The objects send out their stimuli. The child follows the cues, explores the space and locates these objects. The child then collects these objects, explores their properties, returns to the stool and posts them through the appropriate openings of the stool. In this process, both hands and all fingers are involved. It requires holding a 3-D object and recognising the projection of its form in 2-D with exploratory movements.

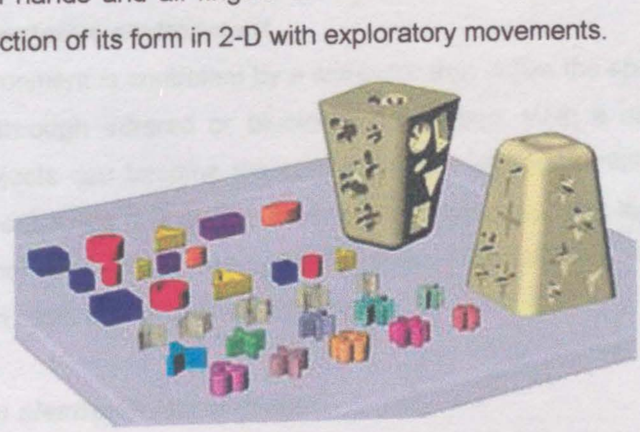


Figure 7.5.22. The objects and the interactive stool.

In order to give clues about this relationship to the child, the interactive stool will warn the child with gentle and short-lasting stimuli if the child is trying to push the collected object through a wrong hole. This warning may be in the form of light, sound or vibration. Otherwise, during the exploration process the stool will remain silent so as not to discourage the child. If necessary, with another command possibility, the stool may point out with gentle stimuli the correct slot. The stimuli may be turned off. The stool may also be used as a piece of furniture to sit on.

Objects and Zog

Zog is a large toy on which the child can sit, lean, or which the child can explore, handle and seek refuge with. On Zog's legs there are deep sockets to place the objects collected from the interactive space (*Figure 7.5.23.*). This time there are no cues in the form of light, sound or movement, but this process relies on the matching skill of the child. Each placed object then becomes a part of Zog, and acts as a control for the environmental conditions. The objects become controls for lights, sounds, airflow, vibration, smell, etc., from within the spatial volume.

When the system is off, Zog is an individual cuddle and a sit-on toy. With the objects, Zog becomes a puzzle and matching toy. As Zog is a large toy, it also provides opportunities to be played with, with more than one child at a time. This can be used as a way to introduce peers, and socialise the children with play towards socially appropriate behaviour.

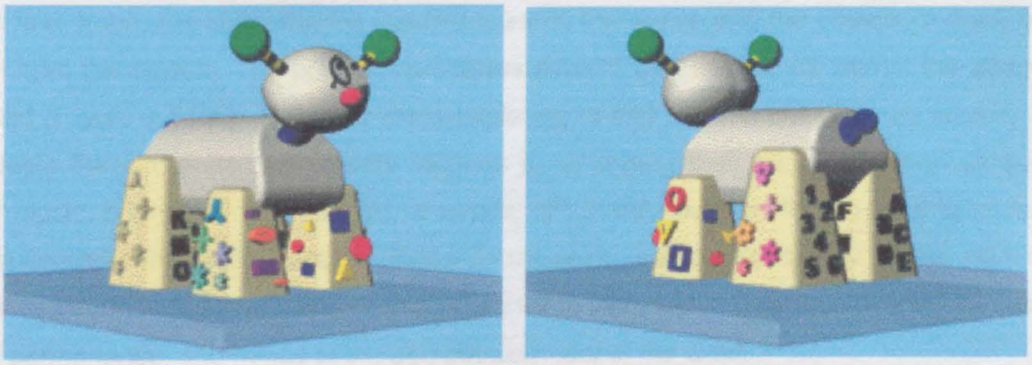


Figure 7.5.23. Zog with the interactive objects.

Objects and the interactive environment

The interactive environment is controlled by a computer that unites the spatial units, the objects, the stool and Zog through infrared or bluetooth connection. With a different setting for the environment, the objects can become the controls of the environmental conditions from their positions in the relevant space (rather than having to be placed on Zog's legs). Without the rest of the elements (the stool, Zog and the computer) this environment can be constructed and used as a sensory stimulation room for rehabilitation purposes.

The computer as an electronic learning aid

The spatial system also involves a computer conceptualised for visually impaired children of pre-school age as an electronic learning aid. The computer has a simple interface that contains the commands 'next', 'back' and 'enter'. Depending on the cognitive stage and learning level of the child, the computer can be adjusted with a Braille keyboard or a standard keyboard. Also depending on the visual impairment of the child, the computer can be adjusted with a magnified touch screen or an embossed display. Apart from being an introduction for the child to computers, within this spatial system the computer serves as a medium between the environment and the child. From the computer the child is able to ask for and gain information on and knowledge of the spatial features, the objects within the space, and the environmental conditions. The child is also able to control the environmental conditions from the computer with the combination of verbal and computer commands. As introducing the child to the computer requires the involvement of an adult, the computer also serves as a medium of interaction between the child and the adult. After being introduced to the computer and getting familiar with the logic of the controls and commands in controlling environmental conditions, the child can be introduced to simple computer games to play with a peer. Providing a computer interface between children with very limited physical capabilities and the environment will help them to keep up with the events occurring in the environment, to contribute to these events by controlling them, and to co-operate with peers who are actively involved in the environment.

INTERACTING WITHIN THE SPATIAL SYSTEM, WITH THE ELEMENTS AND THE OBJECTS (Also see interactive space.ppt in the CD-ROM attached to the thesis)

1. Encountering objects in the space, experiencing different environmental conditions.

At this first stage, the child may be inactive towards the space and the objects, but will receive stimuli from the objects. The objects themselves evident with the stimuli, attract the attention of the child (Figure 7.5.24.). The child starts exploring to find the sources of these stimuli. As the child feels these objects, the objects respond by changing their condition (such as softer or louder music, brighter or dimmer light, or turning off). It will take time for the child to understand the cause-and-effect relationship of these phenomena; but the constancy of the objects and always receiving their stimuli, and in time recognising them within their location, will contribute to *object permanence*, and hence to the *ego development* of the child.

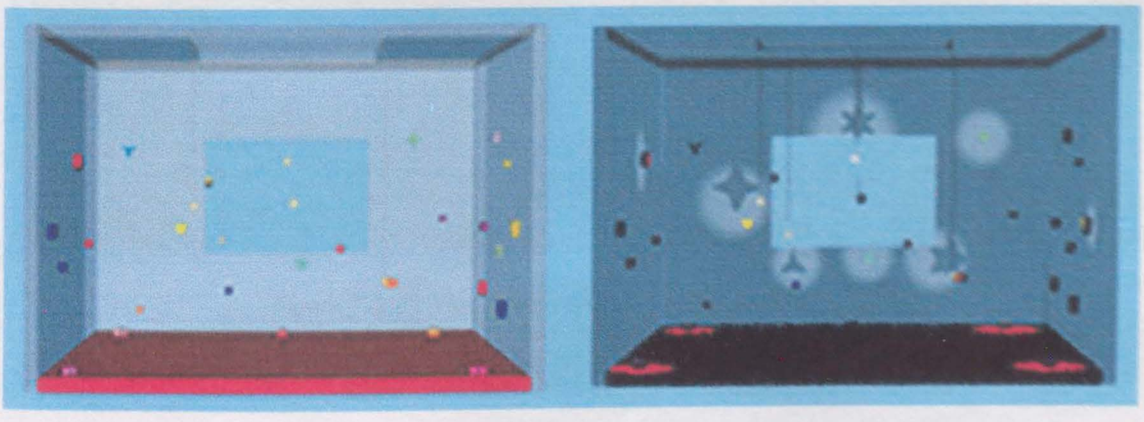


Figure 7.5.24. The environment, the objects and changes of stimuli.

2. Picking up the objects, and posting them into the stool.

This activity offers a more intense understanding of what the handled objects really are, and what they define in 3-D and 2-D space. The child picks up objects and posts them through the slots of the stool, from where the objects disappear (*Figure 7.5.25.*). Yet these objects can be recollected from the stool; the child knows that they continue to exist even though they cannot be perceieved (*object permanence*). The relationship between the objects, the stool and the child, is developed to provide the child with a sense of accomplishment when not receiving warning signals from the stool, a sense of wholeness when the stool is full and the task at hand is complete, and a sense of domination or having control over it, when the child finally sits on it.

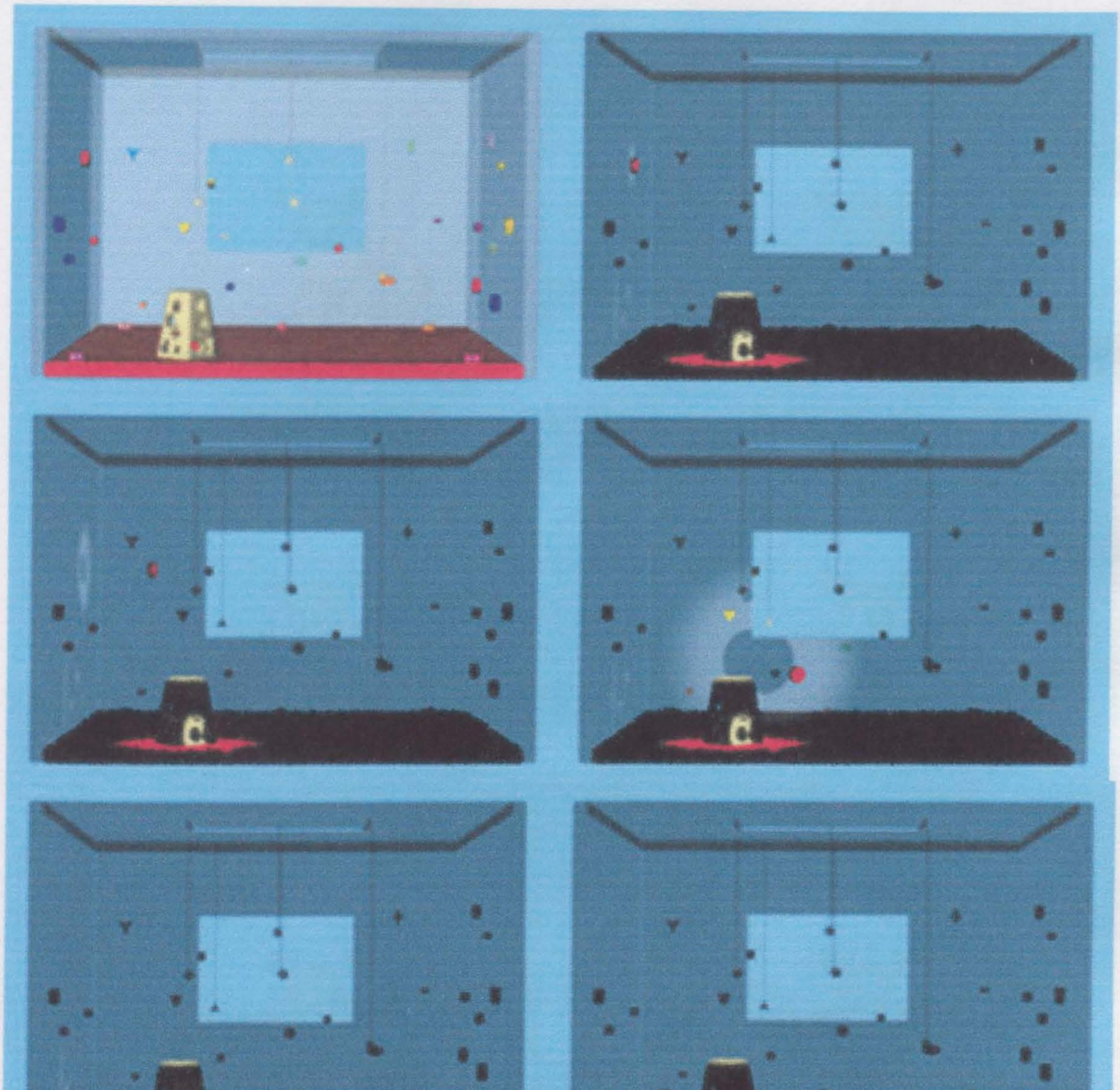


Figure 7.5.25. The objects and the stool in the environment.
When an object makes itself apparent with stimuli, the stool may also interact as an option.
When the object is picked from the environment and posted in the stool,
stimuli from the stool and the environment end.

3. Picking up the objects from about, or out of the stool, and placing them on Zog's legs.

At this stage, the child again matches the objects with their 2-D projection, but this time the objects do not disappear: they become part of another object in this space, thus defining for themselves a new spatial location (*Figures 7.5.26.* and *7.5.27.*). They gain new functions and new meanings for their existence. Within the space and by themselves, these objects are sending out stimuli in a random manner. Within their new location on Zog's legs, they become the reason for stimuli, they become the controls. Once this cause-and-effect relationship is recognised by the child and mastered, the child will be able to interact with the space, and assume its control by creating own spatial atmosphere, with different effects of light, sound, movement, airflow, etc.

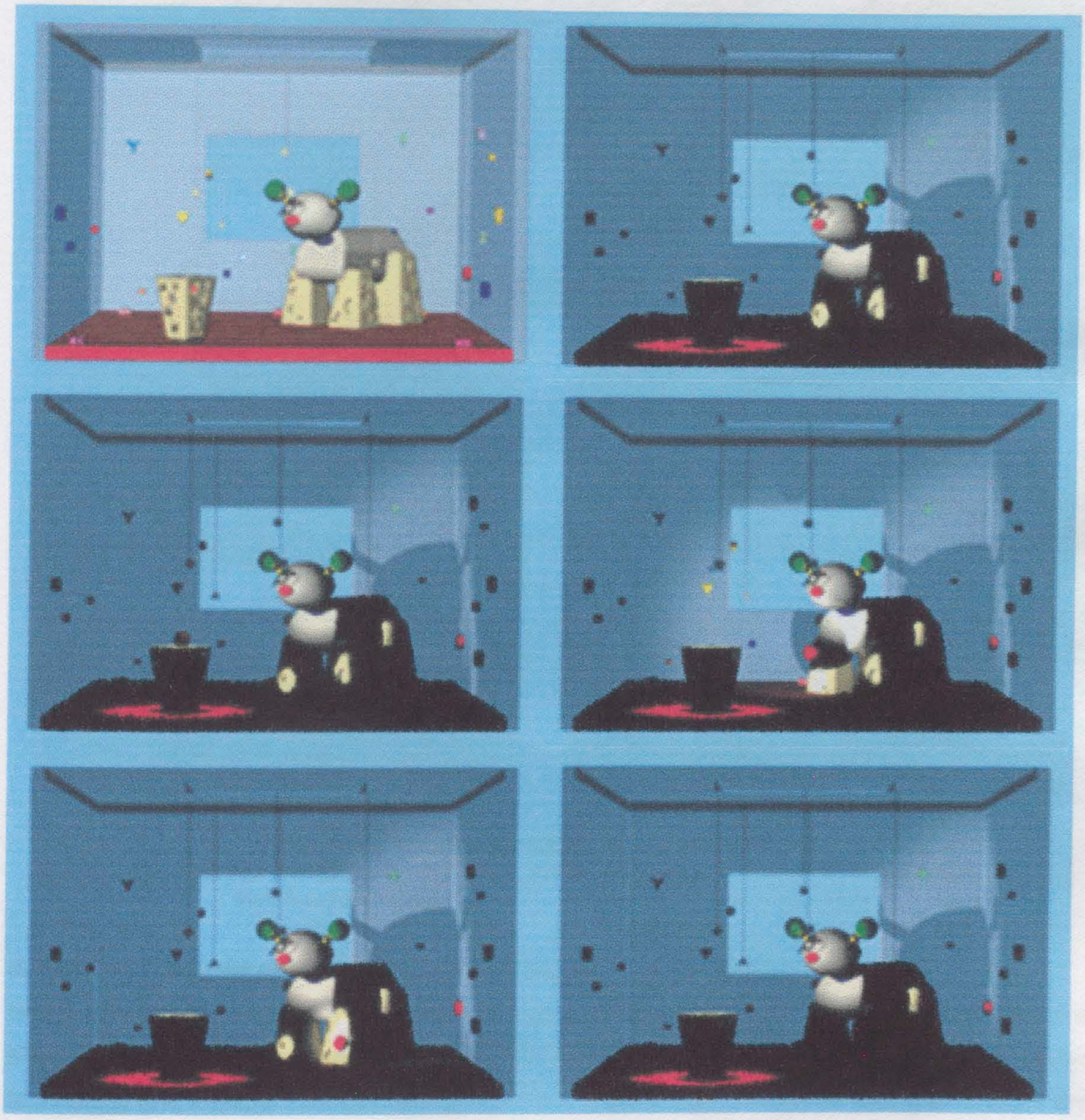


Figure 7.5.26. The stool and Zog in the environment.
The child can pick out objects from the stool and place them in their location on Zog.

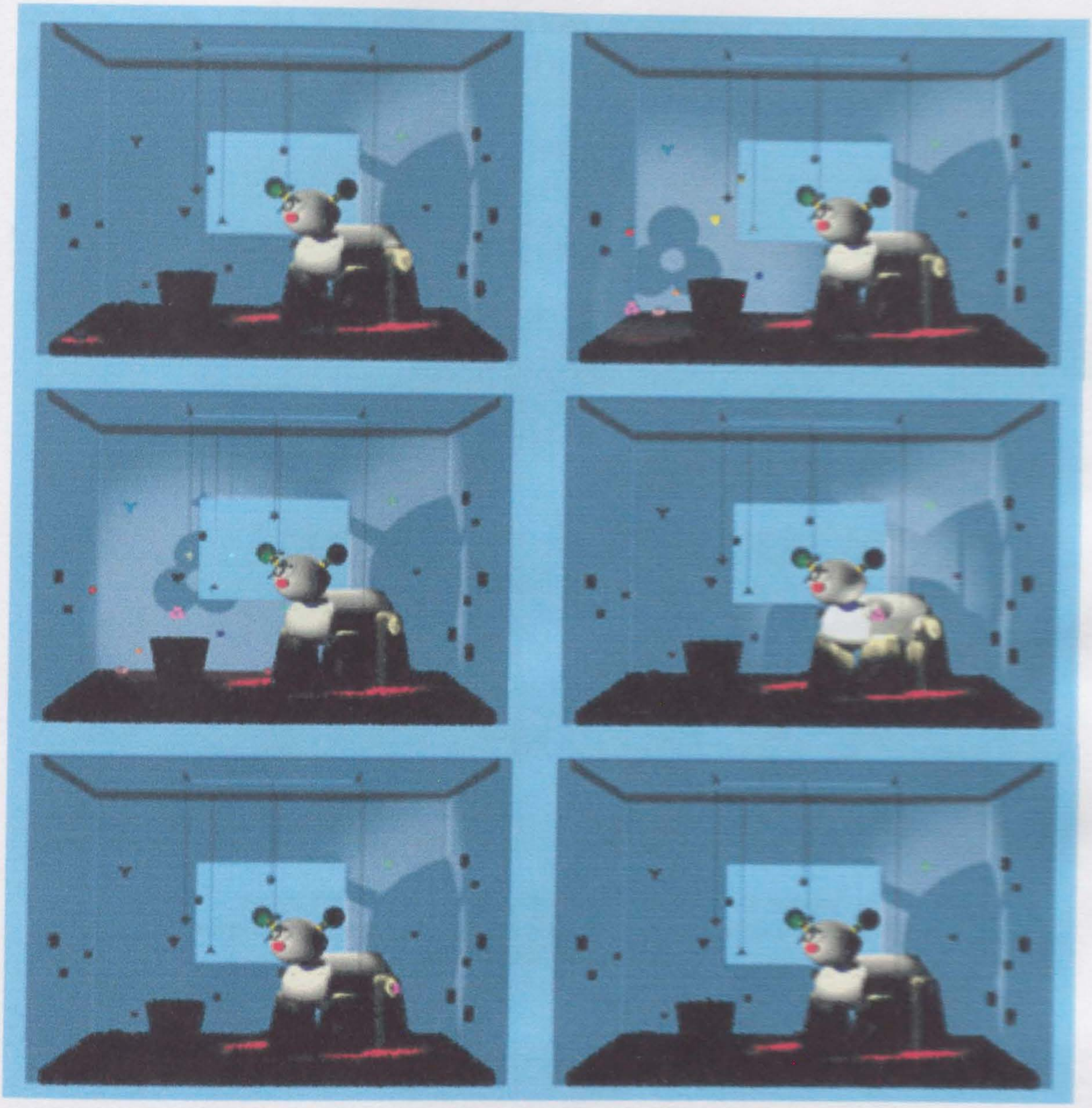


Figure 7.5.27. Objects from the environment and Zog.
The child can also pick objects sending stimuli in the environment and place them in their location on Zog, at which point the stimuli come to an end.

4. Meeting the computer interface, and the logic to computers.

Being able to sit in front of a small computer and learning its logic is not an easy process for a blind child with limited representational abilities and limited patience. But, when communication technology and artificial intelligence is progressing so fast, and children as young as 3 years are playing with computers, it has become a must for the child who cannot see, to also participate. Computers have become a common language and a channel for communication for persons with different abilities, and may provide the blind child the freedom and independence otherwise not availed. As a basic introduction as explained briefly above, the proposed computer interface will act as a medium between the child and the spatial system. Through the computer, the child will learn that the environmental conditions can be controlled, this time in a more systematic manner, by giving logical commands and following a logical sequence rather than just freely pressing controls (*Figure 7.5.28.*). This interaction can then be developed into more complex tasks and games with rules as the child matures (*Figure 7.5.29.*).

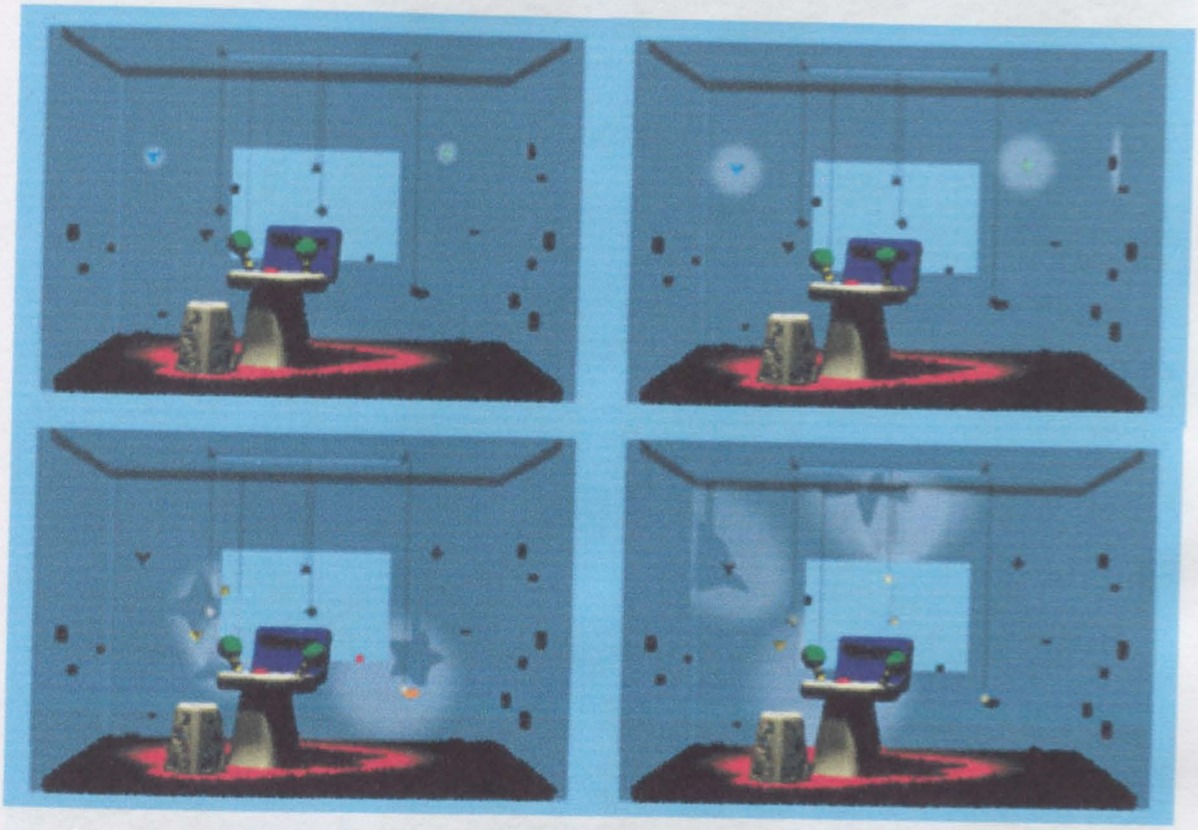


Figure 7.5.28. The computer in the environment with objects.
The computer can be used to control stimuli from objects within the environment, and to create atmosphere.

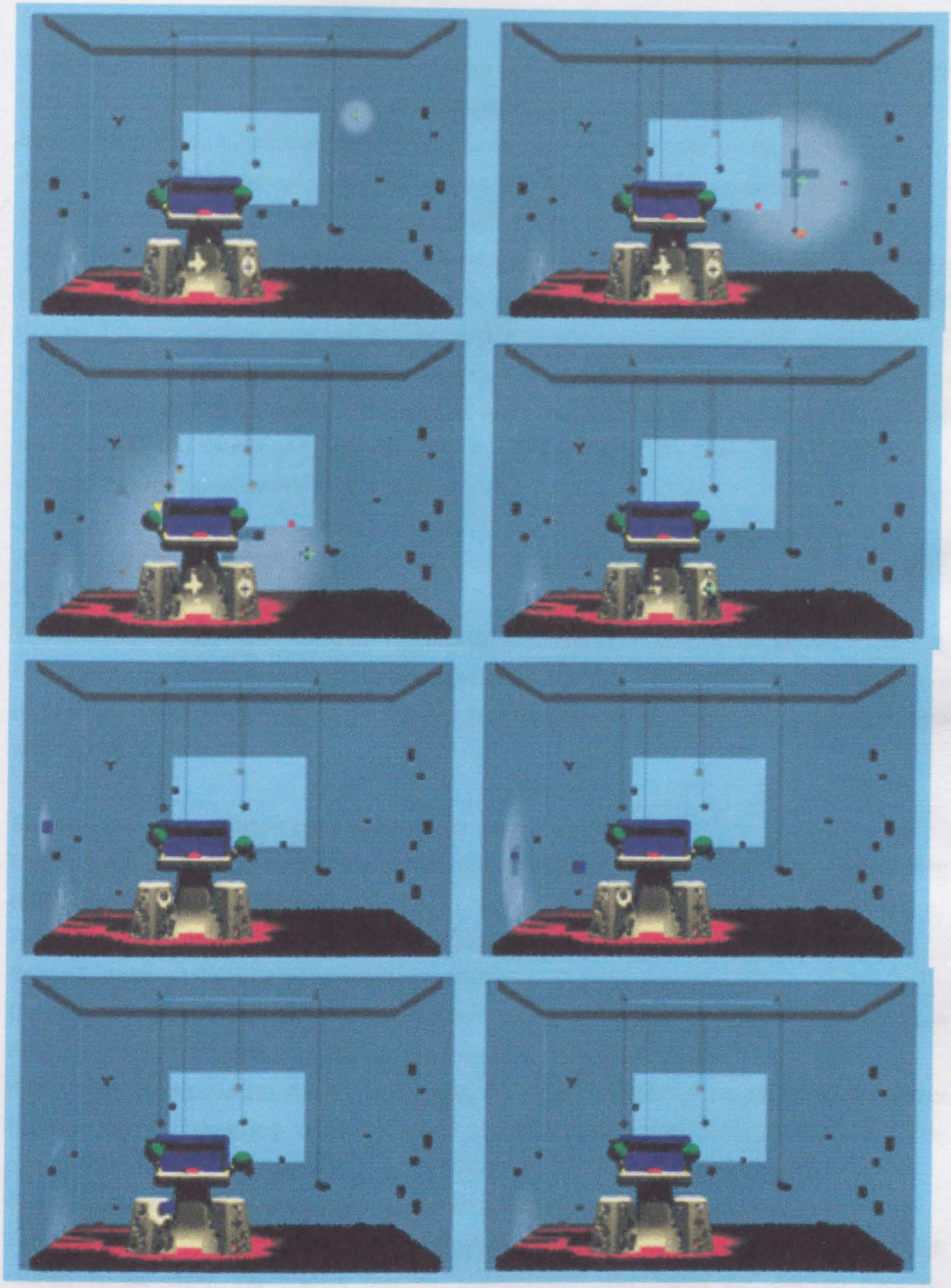


Figure 7.5.29. The computer for two children to play games in the environment.
Each child can select in turns an object with a certain stimulus, while the other will have to search for it, collect it and post it through his/her stool until all objects are collected.

5. Socialising through the spatial system.

Children, particularly the younger ones or those with additional physical disability may need the supervision of an adult, due to the spatial features (steps, partitions) and small objects that might be mouthed. Also, it is important for the child to have an interpreter of the events going on, explaining the things around, and what they do. An adult will have to introduce the child to the stool, Zog, and computer individually, and present the activities offered by these toys as learning experiences. At another stage of social interaction, the aim is to introduce two children, and provide an opportunity in which they can both contribute to the interaction within the spatial system. This may first be done with Zog, which is large enough for more than one child to explore and sit on. The next step will then be to introduce the children to games with rules, which may be by using the computer. Another consideration is to encourage friendship and play for children who can see and cannot see, together. Zog, the computer and the space with its objects, are conceptualised to provide this opportunity.

ANALYSES OF THE SKILLS ADDRESSED THROUGH THE STAGES OF PLAY OFFERED BY THE INTERACTIVE SPATIAL SYSTEM

The analyses presented in *Tables 7.4.1.* and *7.4.2.* towards determining design specifications, had brought forth the skills that were to be addressed with the play activity offered by a toy for a blind child. The stages of play offered by the proposed interactive spatial system illustrate how skill addressing is achieved.

Stage 1. Discovery: *Child-Object Relationship*

Being aware of the existence of the objects. Feeling different forms and details, experiencing different materials and textures.

Aim: object permanence, ego development, co-ordination of gross- and fine-motor skills.

Stage 2. Activity: *Child-Object-Space Relationship*

Deciding to locate more objects. Discovering new objects within the space. Discovering what can be done with these objects in relation to the self and to the space.

Aim: onset of locomotion, spatial awareness, orientation, navigation, object location, shape discrimination and matching, understanding of cause-and-effect relationship, refinement of fine- and gross-motor skills.

Stage 3. Learning: *Child-Object-Teacher Relationship*

Supervision of an adult; adult acting as the information supplier of basic concepts and knowledge related to the child, the objects and the space; adult also being the medium between environmental events and the child by explaining concepts such as: function, quality, quantity, size, time, space, action-reaction, foreground-background, etc.

Aim: development of cognitive skills, development of representational abilities, learning.

Stage 4. Imaginative play: *Child-Symbol Relationship*

Encouraging the child into imaginative play, such as using an object as something else, or personification of the dog, like 'going on a ride', feeding, talking to, making it talk, etc.

Aim: development of symbolic representation, development of imaginative skills.

Stage 5. Socialising: *Child-Object-Other Child Relationship*

Playing with a peer or peers with the possibilities offered by the objects and the space, demanding the interaction of the children by using social behaviours and skills such as: turn-taking, co-operating, creativity, imagery, representation, animation, playing with rules, practising socially appropriate behaviour, etc.

Aim: development of emotional skills, overcoming behavioural problems, socialisation, imagination, creative problem-solving, symbolic representation, self-representation.

FROM ENVIRONMENTAL AWARENESS TO COMMUNICATION WITHIN AN EXTENDED SPACE: THE HAND ZOG COMMUNICATION TOY

The maturing visually impaired child must be encouraged to become more independent in daily activities. This can be achieved by providing the child with the possibilities to open out into the spaces of daily life, and then in time, into spaces outside daily routine. Over-protection of a child would bring insecurity, yet children and families have to feel safe as children join in spatial and social environments apart from their own. As a complementary element to the interactive spatial system, but working individually, the next conceptual idea describes a hand-held communication device, which also works as a pathfinder and location indicator for the blind/visually impaired child.

Hand Zog as a Personal Communication Device

- Hand Zog is a telecommunications device with a friendly interface adapted to children who cannot see. Through this device the children can talk to parents, teachers or peers. If they feel lost or insecure, they can contact persons through verbal command.
- Hand Zog is microchipped with information on one child. This indicates the location of the child, enabling parents or teachers to follow the child's well-being through a computerised device.
- The child's belongings are microchipped and entered (or somehow connected) into Hand Zog. When the child wants to find a belonging (bag, coat, another toy, the other pair of a shoe, a crayon that falls and rolls away, etc.), he/she says the name of the item aloud, or gives search command on Hand Zog. The Hand Zog locates the item and produces a stimulus, the intensity of which changes depending on whether the child is near or far from this item. Or else Hand Zog makes the microchipped item produce a stimulus that the child can track. The child will also be able to understand whether the item is in the same room or not, through verbal or coded sound or vibrating information supplied by Hand Zog.
- The objects in the house or school environment, are also chipped and the child no longer has to wait for the assistance of adults to find things and get started into an activity.
- If the child mislays the Hand Zog, the parents or teachers can locate it from their computerised device. They enter an item the child is wearing (either on their device or on the Hand Zog left behind), and thus locate the child through this item.
- Hand Zog is also a path-finder. As a supplement to the cane, Hand Zog can be used to keep in track in pathways defined and saved in it. Hand Zog will also inform of the location and

nature of obstacles to be encountered on the way. The nature of this information will be in the form of speech, or can be codes of sounds, lights or vibrating movements that the child will have to learn to interpret.

- The child can enter and save his/her own chipped belongings in the Hand Zog's memory. The child can also select from among different options of stimuli that he/she wants the Hand Zog to produce, while seeking for an item.
- The child will be able to wear Hand Zog on the body to free both hands. He/she can pick it up and place it separately, as well.

Hand Zog as a Personal Toy

A small hand-held toy Zog could be used as an introduction to the big Zog and in time also to the hand-held communication device described in the previous section. The small Zog is to become one child's property. If there can be established an emotional bond between a child and the hand toy, this may also mean that the child is willing to communicate further with the external world, and may express this with contacts made through the toy, as children may use toys to express their own feelings and wishes, pretending these feelings and wishes belong to a toy. Presenting the small Zog to a child who has communication difficulties may suggest that the teacher and the child are soon going to visit the actual big toy and the child will be playing with it. Having the same toy in a different scale may not mean the same to the child, so to give it the same feel the small Zog (*Figure 7.5.30.*) may be made by using similar materials on the same parts of the design as a reference.

Figure 7.5.30. A study model of Hand Zog as a single child's toy.

The small Zog is conceptually developed to be one child's toy, whereas the large Zog belongs to many children. As a concept the whole idea of Zog is developed to become a personal friend and a common experience for the children who meet it.

OUTPUT: THE FINAL DESIGN CONCEPT OF THE INTERACTIVE ENVIRONMENT AND ZOG

7.6. DESIGNING THE TOY SYSTEM

INPUT: THE FINAL DESIGN CONCEPT OF THE INTERACTIVE ENVIRONMENT AND ZOG

Once the final concept was established, the final look of Zog, the elements and the spatial environment were determined through sketches, drawings and models. Ergonomic considerations were solved by the use of human factors source books and with rough models (*Figure 7.6.1.*) to be able to determine the elaborated measures. The technical drawings were prepared for the manufacturing process (*Figures 7.6.2.*), and the project was modelled in detail on the computer (*Figures 7.6.3.*) in Rhinoceros (NURBS modelling programme for Windows Version 1.1). These drawings represent the FINAL DESIGN DECISIONS. Animated presentations were prepared to give an idea of how the project would actually work.

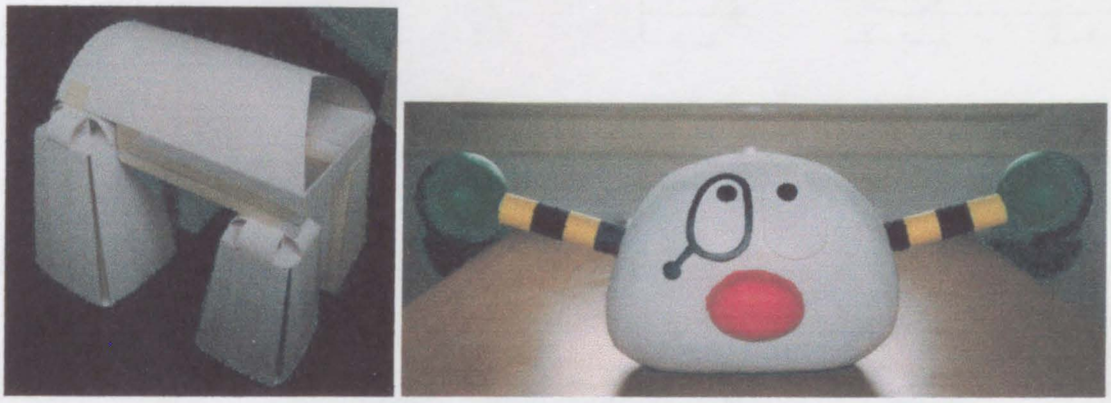
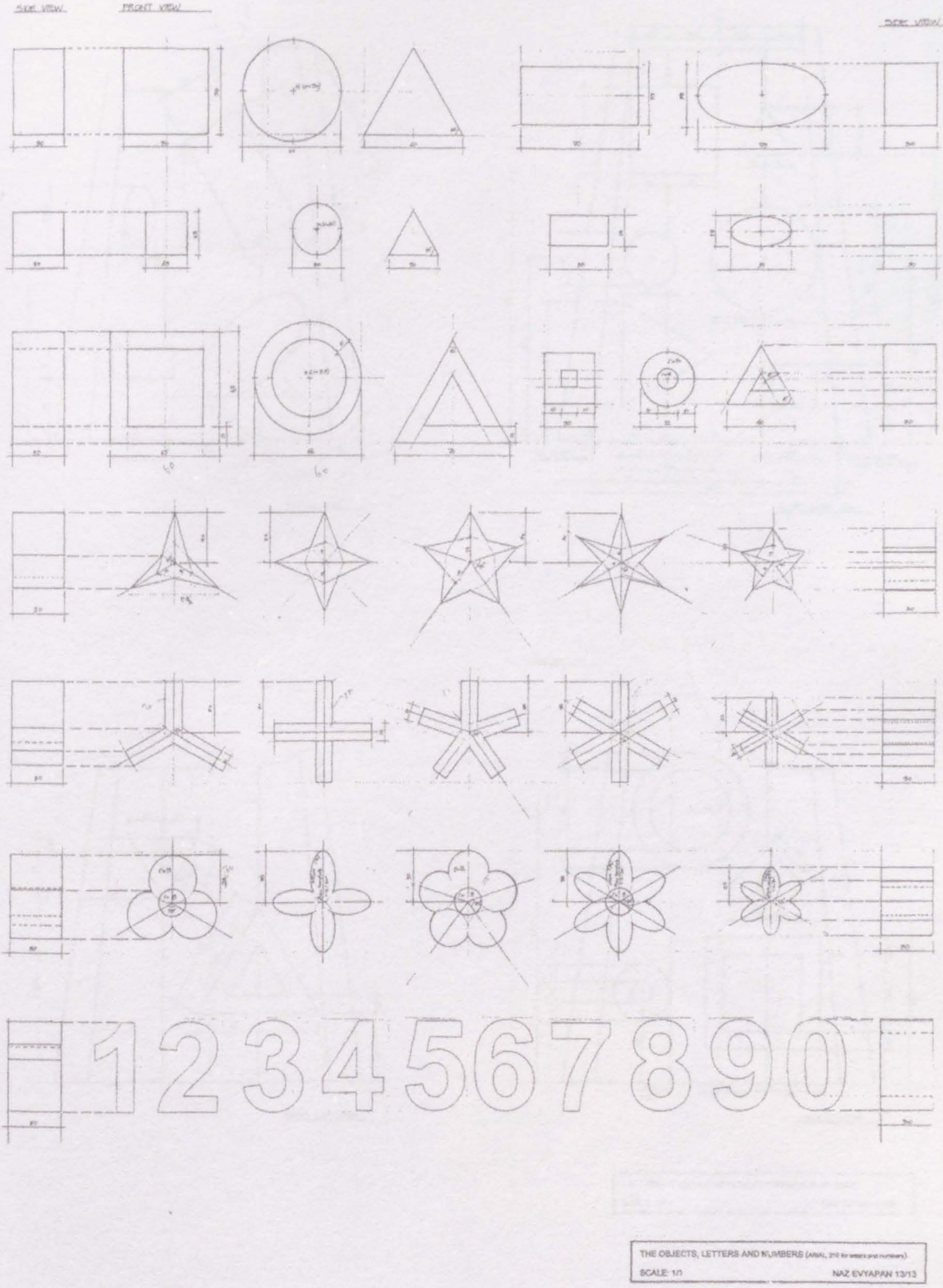


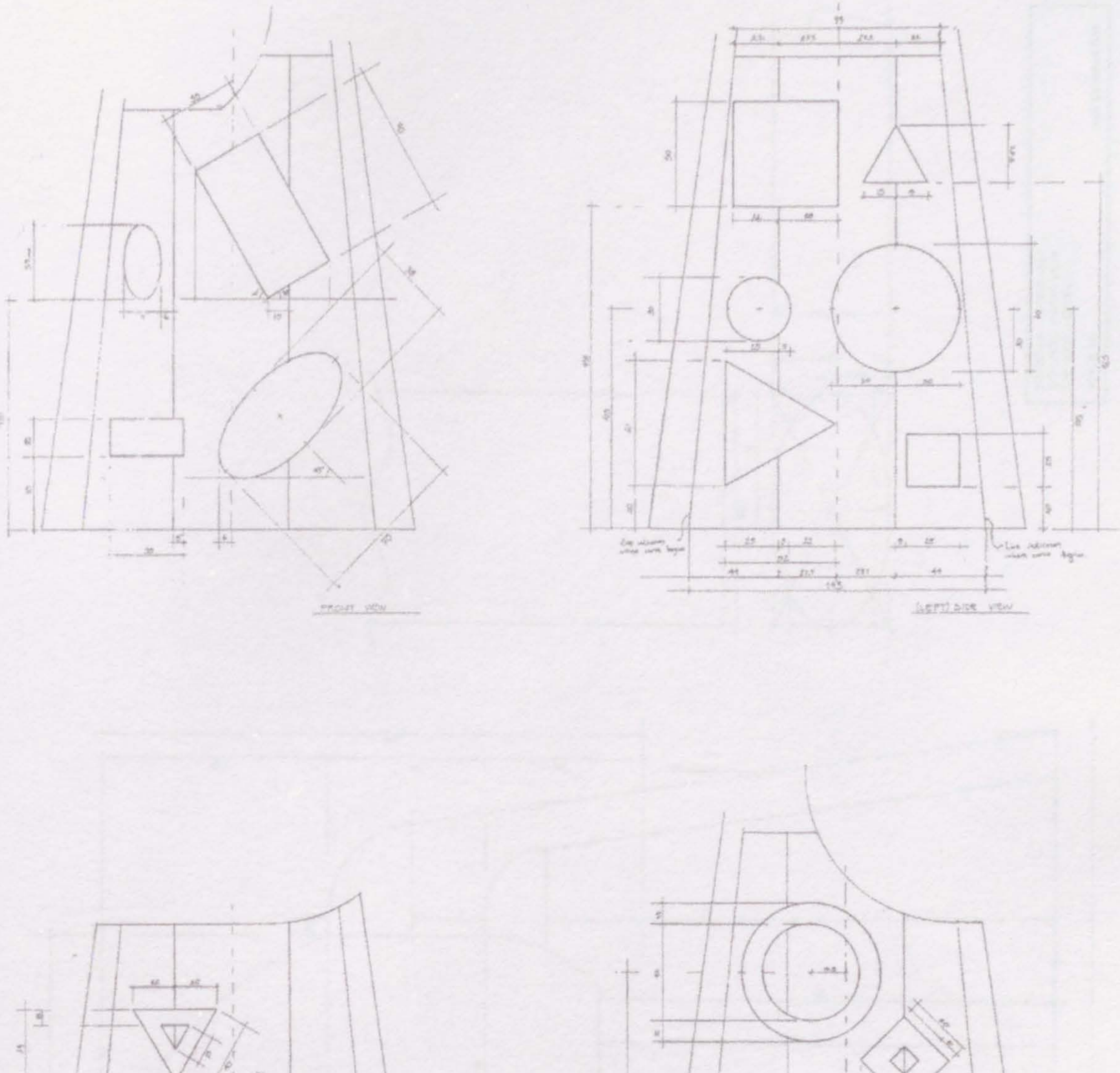
Figure 7.6.1. Rough models of the body and face.

As the project is of a large scale consisting of numerous different features and activities, due to limitations mentioned in *Section 7.4.*, it would not be possible to manufacture and test it as a whole. Therefore only the abstract dog and the objects that could be placed on its legs were chosen to be manufactured and tested among children to see whether it would evoke any play interest.

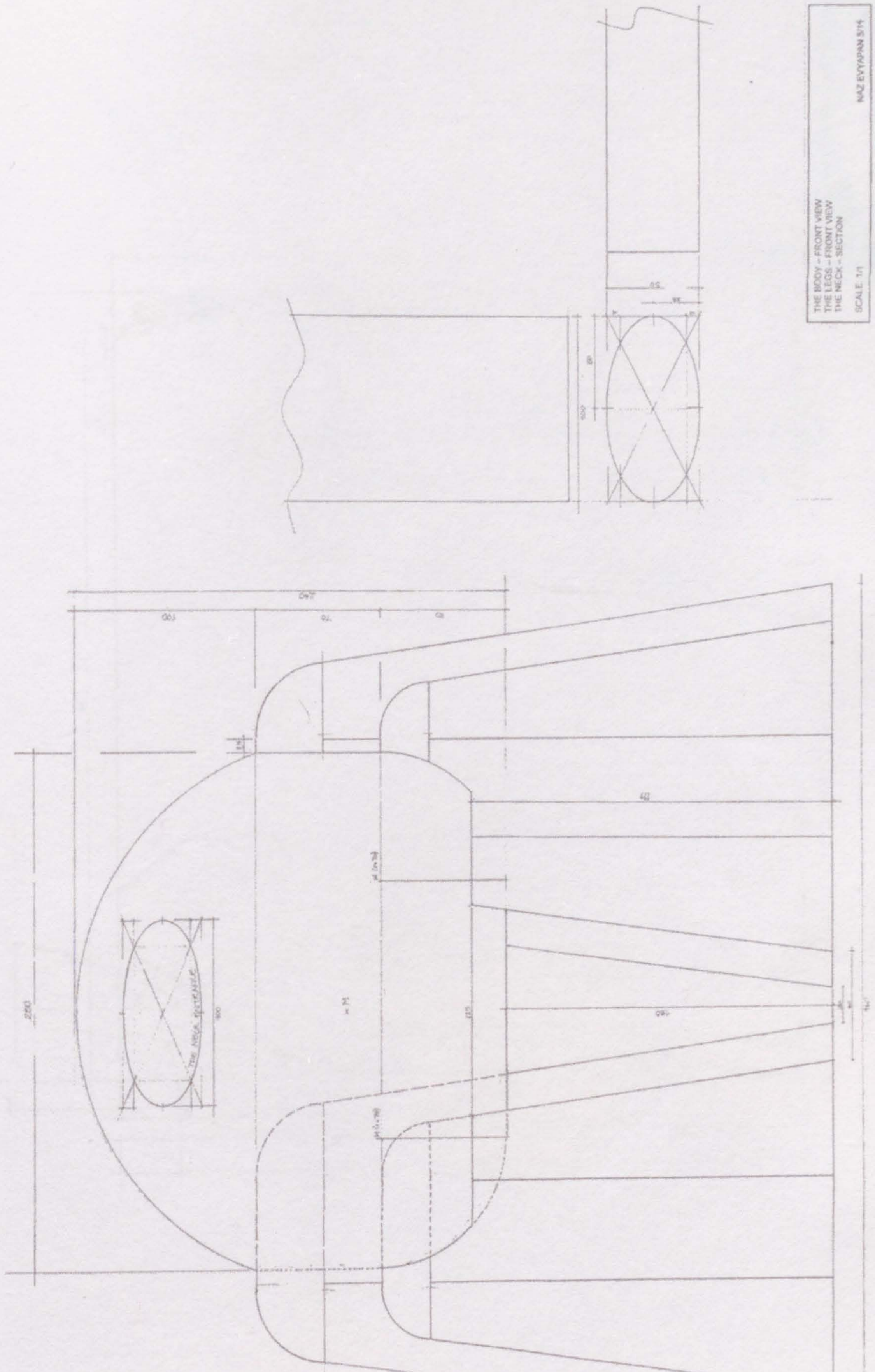
The toy involves diverse materials to provide touch-and-feel experience, owing to the functions of different parts and the production techniques used. It was decided that the legs should be of dense plastic, and vacuum-formed to keep them hollow. The body and head were to be of moulded foam, covered with vinyl. The objects are all of different material, such as wood, plastic, foam, sponge, fabric, etc., some to be made by hand, and plastic and foam parts to be moulded.



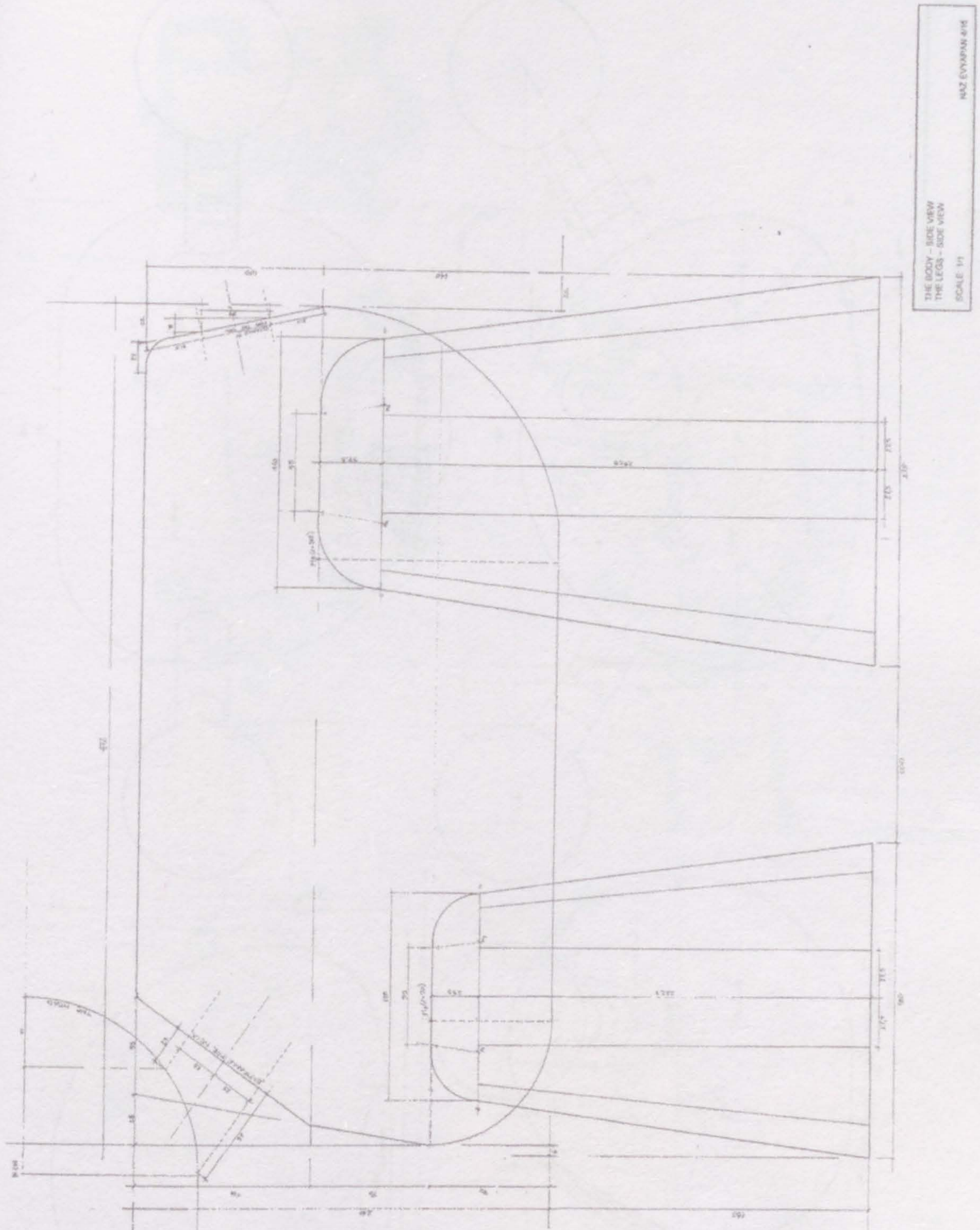
Figures 7.6.2. Samples of technical drawings of features of Zog prepared for manufacturing.
a. The objects.



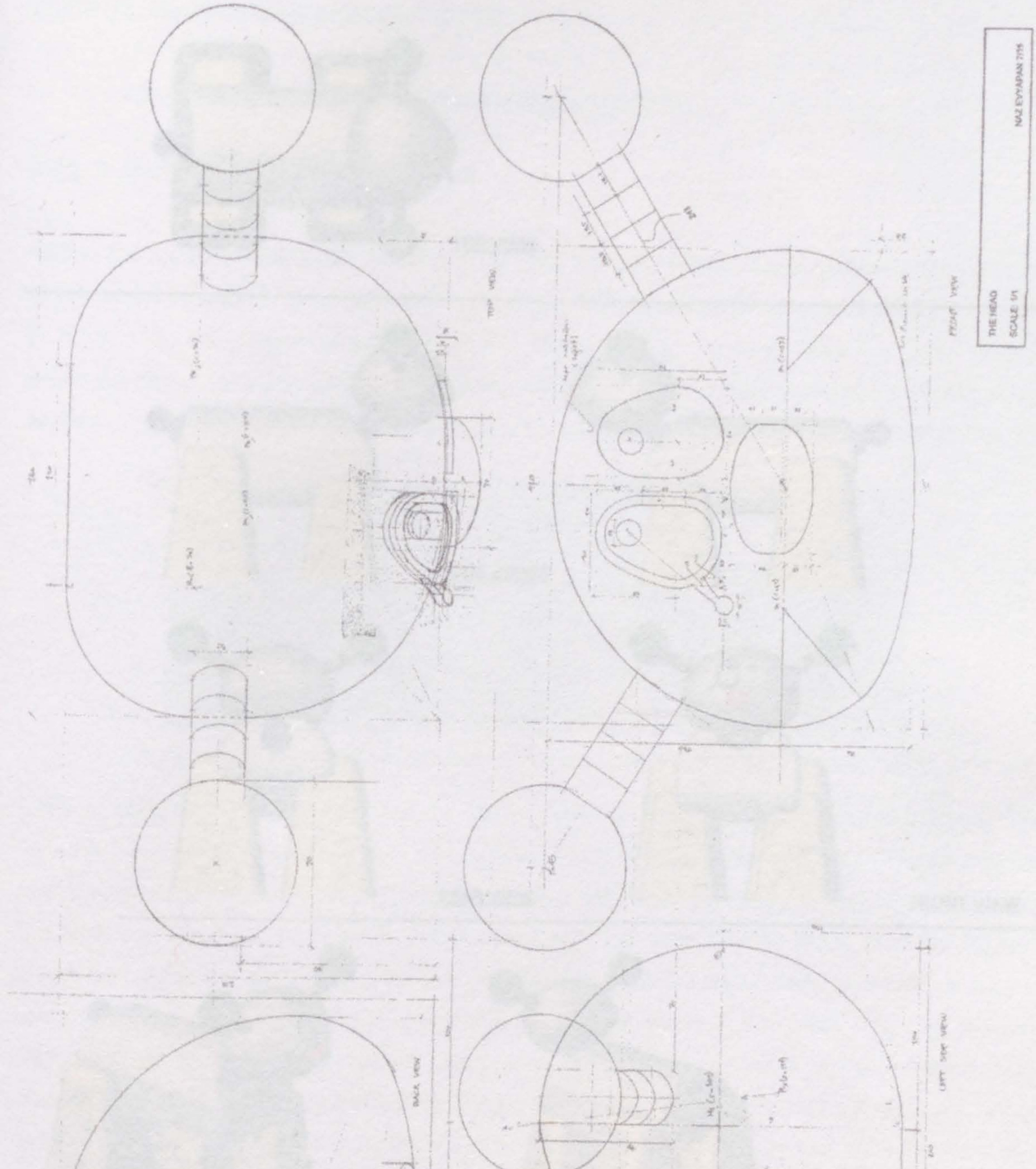
b. The front left leg.



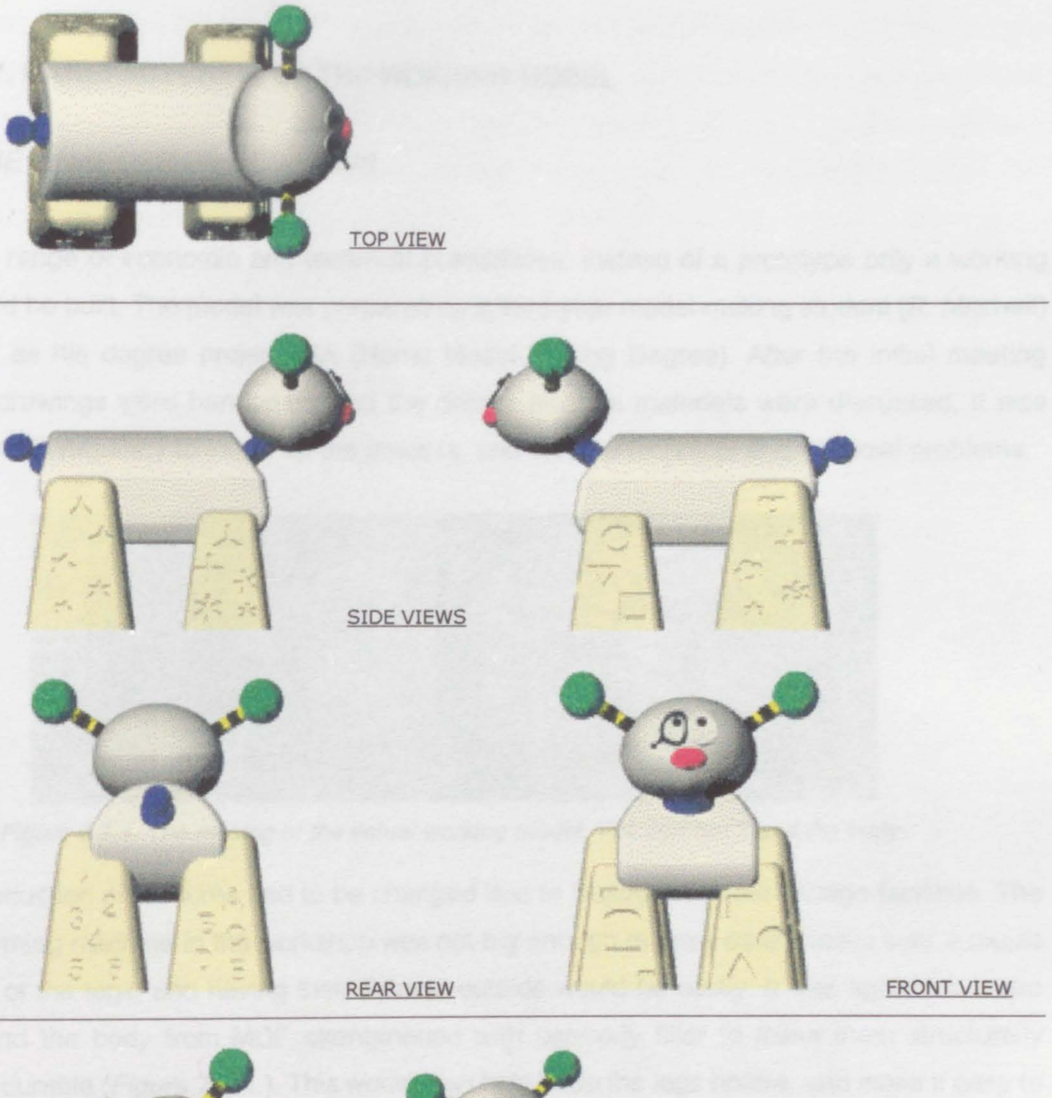
c. Front view of body.



d. Side view of body.



e. The head and horns.



Figures 7.6.3. THE FINAL DESIGN DECISIONS: The project modelled on the computer.

OUTPUT: THE FINAL DESIGN DECISIONS

7.7. MANUFACTURING OF THE WORKING MODEL

INPUT: THE FINAL DESIGN DECISIONS

Within the range of economic and technical possibilities, instead of a prototype only a working model could be built. The model was prepared by a third-year model-making student (R. Mitchell) at K.I.A.D. as his degree project (BA (Hons) Model-Making Degree). After the initial meeting when the drawings were handed in, and the details and the materials were discussed, it was agreed to meet regularly to follow up the process, and discuss technical and financial problems.

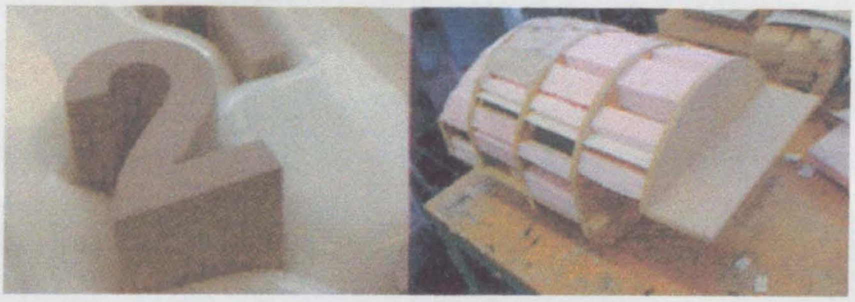


Figure 7.7.1. The making of the actual working model: The number 2 and the body.

Certain production procedures had to be changed due to limitations in the college facilities. The vacuum-forming machine in the workshop was not big enough to draw down plastic over a mould of the size of the legs, and having them formed outside would be costly. It was agreed to make the legs and the body from MDF strengthened with car-body filler to make them structurally sound and durable (*Figure 7.7.1.*). This would also help keep the legs hollow, and make it easy to open sockets on the legs in the shape of the objects that would fit into them. The objects were negotiated down to a lesser number due to technical reasons; more sockets meant more openings on the legs, and less structural strength. The final model was made of six parts, which could be put together and then removed: four legs, one body, and the head, with the neck and two horns. The designer continued working on the model, firstly by padding the seat for softness and covering it with vinyl. The graphical layout on the face was corrected, and the horns stabilised on the head, as they could be broken off with vertical pressure. The objects on the legs were completed, and tactile cues were added onto them and around their sockets on the legs. A tail that vibrates when pulled was added to the body. Electronic details were made; flashing lights were added to some sockets, and sound details were added onto the sockets of letters and numbers (so that when they are placed in the sockets they speak out the letter or the number). At this stage the working model was considered to be complete and ready for field-testing.

DESCRIPTION OF THE WORKING MODEL

The Body, Head and Tail

The height of the body (the seat) is 420 mm from the ground, and the width is 280 mm. The front legs are shorter than the back legs. When the child sits on the toy with legs apart, he/she can place feet on the protruding bits of the front legs, and can hold on to the horns. The top of the head is 585 mm high off the ground. The yellow and black striped horns protruding from the head end with large green spheres (diameter: 90 mm) that are soft and squeezable and would absorb the effects of any bumps. The facial features consist of a squidgy red nose, and two large eyes with a black iris on each. To distinguish the left and the right eyes, the right eye is framed with black, with a teardrop shape pointing downwards. The neck is blue, and is surrounded with a white collar with a bell that disguises the joining detail of the neck to the body. The tail of sponge covered with blue terry towel, when pulled, returns to its position with vibration (Figure 7.7.2.).

Figure 7.7.2. Zog, the abstract dog.

The Legs and the Objects

The legs are of a creamy yellow colour, and they contain sockets into which objects fit. On the *front left leg*, there are sockets for sponge flowers of three and four petals, and for the solid triangle and square prisms and cylinder (*Figure 7.7.3.*). From the flower and other forms, tactile patterns lead to a musical component, and when the related shape on the component is pressed, different nursery rhymes are played.

Figure 7.7.3. The front left leg and its objects.

The *front right leg* has sockets for the hollow square, triangle and circle, and the five- and six-petal sponge flowers (*Figure 7.7.4.*). The sockets of the hollow forms are framed with thin black tactile lines to provide a visual target area as to where the shapes belong. The sockets of the sponge flowers are surrounded with tactile cues as to the number of petals. All the sponge flower objects are soaked in water scented with peppermint, apple, cinnamon and rosewater.

Figure 7.7.4. The front right leg and its objects.

The *rear right leg* contains the cross-shaped objects with three, four, five and six arms in its sockets (*Figure 7.7.5.)*. It also has tactile frames for the three-, four-, five- and six-edged stars. The crosses are covered with different rubber textures for the child to match with the textures framing their sockets. The stars all have electronic components in them that flicker light when moved, shaken or hit. They are made of transparent plastic material, and also contain beads in them and act like a rattle.

Figure 7.7.5. The rear right leg and its objects.

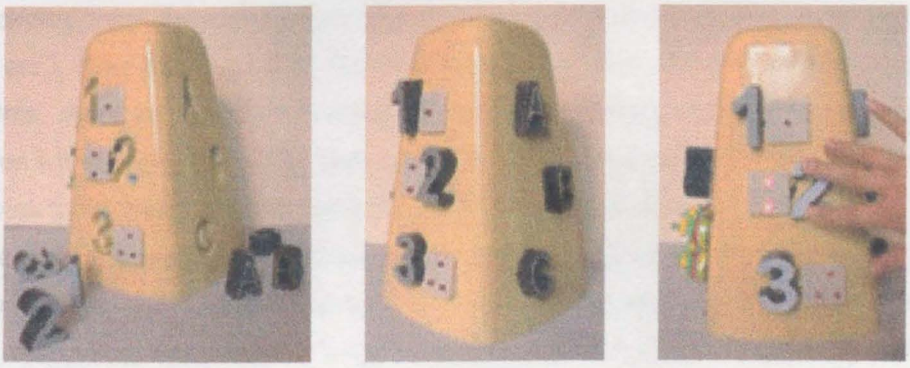


Figure 7.7.6. The numbers and letters on the rear left leg.

The *rear left leg* contains the letters A, B and C, and numbers 1, 2 and 3 in solid 3-D form (*Figure 7.7.6.*). The letters and numbers are placed for children who have residual vision and will be able to read large print. There are also Braille characters of the letters and numbers placed next to their sockets. When placed in their sockets, these objects contact an electronic detail that speaks out the name of the letter or number. Again, the numbers initiate red lights placed next to their sockets (one light for the number 1, two lights for the number 2, etc.). On a third face of the leg, the number 4 in 3-D is attached with velcro (*Figure 7.7.7.*). Below it, there are four plastic objects with felt decorations placed in a black-framed visual target area with the help of magnets. These objects represent the number 4 in terms of being the four components of a group and being pieces to count and place one by one.

Figure 7.7.7. The number 4 and its objects on the rear left leg.

The Activities

The learning activities that can be done with the toy are grouping, counting, sorting, matching, placing-displacing, talking about properties of shapes (surfaces, edges, corners, curves, etc.) and about properties of material (soft, hard, warm, cold, sponge, wood, plastic, fabric, heavy, light, etc.). Zog is designed to be dismantled, so that each leg operates individually as separate toys. Therefore the toy offers shape matching, and discrimination, requiring fine- and gross-motor skills in two stages:

- The child begins with the simple group of objects on an individual leg, and then moves on to a leg with more complex forms. With the selection, layout and presentation of the objects, a sequential experience with objects is offered: simple, basic forms to begin with (triangle, square, circle), then discovering the differences between similar objects (solid triangle, hollow triangle, etc.), then passing on to more complex forms with different properties (flowers with curvy forms, stars with pointed corners, crosses with straight arms). The objects also have differences within the groups they belong to: the basic forms have different numbers of edges, the complex forms have different numbers of petals, arms or corners.
- When the child is more skilled he/she can play with the toy and all its legs as a whole, in a more mobile way, and search for objects and their sockets in a more spatially complicated manner and with more effort. Apart from looking for objects, it is hoped that the child gains pleasure and enjoys the stimuli provided all around the toy.

OUTPUT: THE MANUFACTURED WORKING MODEL

7.8. FIELD TESTING THE TOY

INPUT: THE WORKING MODEL

Zog offers activities which will contribute to a blind child's introduction to objects and their location in space, so it is important to assess whether Zog does encourage the carrying out of activities related to the objects. To observe this, a non-experimental research was carried out, using participant observation. That is, the participating children were observed and the observations systematically recorded during a predetermined time span of free play session with the toy.

SPECIFICATION OF THE RESEARCH QUESTION

In a study by Murphy *et al.* (1986) the subjects' playing with toys has been described and measured as *toy contact* and *toy manipulation*. The same terms will be used for this research. The research question that represents the aim of this study (Drew and Hardman, 1988) can be stated as follows:

How do blind and visually impaired children play with the toy specially designed to encourage interaction between the child and toy-objects, within a spatial territory defined around it?

To answer this question, the following acts of the child in relation to the toy and the behaviour then exerted, will be observed:

A. Contact with and manipulation of the objects of Zog (discovering the objects, their locations and the activities they offer).

B. Contact with and manipulation of Zog as a whole (activity with/around Zog, use of space defined around Zog).

C. Avoiding toy contact and manipulation with Zog and/or its features.

D. Social interaction with the teacher about the objects and activities (learning/ socialisation).

E. Imaginative play with Zog.

F. Repetitive/inappropriate play behaviour with Zog.

G. Self-stimulating behaviour when faced with Zog.

The way these behaviour may take place are given in a list in *APPENDIX B*.

THE HYPOTHESIS OF THE RESEARCH

Drew and Hardman (1988) define the hypothesis of a research as a theoretical conceptualisation or an idea or guess, regarding how the researcher anticipates the results and their indications. The hypothesis for this research was: *In the presence of Zog, children will make contact with Zog and its activities, they will engage in toy manipulation by operating the stimuli and they will interact with the teacher in relation to Zog.*

THE METHODOLOGY OF THE OBSERVATION

The observation towards field testing was carried out in a school for blind children located in the Kent area. The actual observations began in November and were planned to continue the following two weeks, with three days of observation each week. It was difficult to provide a controlled testing environment with limited variables in a real-life situation. As it was not a prototype, the toy could not be sent for safety testing. As a principle it was aimed at complying with safety regulations for the design. It was decided that the play sessions during the testing of the toy should be supervised by a member of staff or a teacher apart from the observer during field testing. As it could make the children feel insecure, as well as keeping them away from the class activity, it was not found appropriate to extract the children from their classroom setting from among their peers for a long time. It was decided that the children would be accompanied by a teacher to make them feel secure, also encouraging them into interaction with the toy, apart from only supervising the sessions. The study was done to assess the designed toy and not the participating children.

The teacher who participated in the play sessions with Zog was given basic instructions on how to introduce the toy to the children. This was necessary for all the children to have the same standard introduction before they began to play with Zog in their individual ways. The instructions involved: introducing Zog starting from its face and then body and tail (to give an idea of the whole, and where the features belong), then introducing the objects on the legs, starting from the basic shapes (on the front surfaces of the front legs) to more complex ones, also trying out the activities these objects and features involve, as they are being shown.

The Setting

The observer was given a small room with one window and artificial lighting from the ceiling. The room was used as a storeroom, therefore in some of the sessions there were boxes stacked around the walls. Zog was set up in the centre.

The Participants

Four participants were observed in two play sessions each[9]. The description of the participants, including age, developmental stage, gender, type of visual impairment, history of visual impairment, and other physical and cognitive disabilities, is given in *Table 7.8.1.*.

In their classroom, the participating children had half-an-hour of a free play session and half-an-hour of a structured play session in the mornings.

[9] The school appointed five children whom they believed would be responsive to the toy. Only four of these children were available during the weeks the research was booked. Whereas previously it was decided that the study would be carried out in 20 play sessions (10 play sessions with Zog and 10 sessions with a toy found in the market for a comparative study), this idea did not fit with the timetable and schedule of the school. Not to distract the children from their natural environment and not to keep them away from their classes, it was found suitable to play with them during their half-an-hour free play sessions in the mornings.

- In these play sessions, C. was actively involved, asking questions and playing in explorative and imaginative ways. He also tried to involve his friends in his play, but generally had to have his teacher play with him as his friends were not always responsive.
- J. was good tempered most of the time and with direction from his teachers, he also played in explorative ways with the toys. Yet, J. was reluctant in handling things until he got used to them, and his play was in general of a discovery nature. Physically, he was not active, and was having mobility training.
- R. was a physically active and an inquisitive child, but he preferred to play alone, searching for his favourite items. He was mostly engaged in activity play.
- M. was not physically active at the time, and remained passive in front of the toys she was given unless she had directions and encouragement from her teachers.

All the children enjoyed music, and they all moved their bodies according to its rhythm.

Table 7.8.1. The Participating Children

Child	Gender	Age	Type of Visual Impairment	History of Visual Impairment	Use of language	Other physical or cognitive disabilities
C.	M	2 y, 9 m	Albinism (partially sighted, can see relatively well)	From birth	√	None
J.	M	3 y, 1 m	Cortical visual impairment (severe visual impairment)	From birth	X (understands what he is told)	Limited use of the legs due to a slight physical problem
R.	M	3 y, 3 m	Cortical visual impairment (severe visual impairment with slight residual vision on the left eye)	From birth	√	None
M.	F	2 y, 11 m	Microphtalmia (totally blind)	From birth	Limited (understands what she is told)	Limited mobility due to lack of physical experience

The Observation Methodology

The observation methodology was chosen as narrative/free description and tracking/structured description. Narrative description involves watching a child and noting down everything that happens; tracking description is recording his/her movements on a graphical layout (Sharman *et al.*, 2000). The duration was determined by the interest of each child, and the sessions took around 5 to 15 minutes. The narrative descriptions, in detailed account in *APPENDIX C*, were then investigated so as to understand the behaviours that were displayed, and were presented in an evaluation chart for each session. The charts display the behaviour types listed earlier in this section, and whether they have occurred during play. Tracking sheets were used to represent the spatial movements of the children and with which features of Zog they interacted. The evaluation charts can be found in *APPENDIX D*, and the tacking sheets in *APPENDIX E*.

OUTPUT: THE WORKING MODEL AND DATA COLLECTED FROM THE OBSERVATION

7.9. EVALUATION OF THE OBSERVATION TOWARDS ASSESSING THE FINAL DESIGN

INPUT: THE WORKING MODEL AND DATA COLLECTED FROM THE OBSERVATION

ISSUES AS INPUTS ENCOUNTERED DURING OBSERVATION

The Individual Abilities and Interests of Each Child

The participating children had individual differences, which shaped their interest in different activities and features. C. has relatively good sight, and was more mobile and inquisitive compared to his peers in the playgroup. He was attentive to events happening in his surroundings, and seemed to have more outdoor experience, which he incorporated into his play. He was developmentally age-appropriate, quite boisterous, and could have a short attention span unless he was really interested in the play. C. was therefore the child who made the most out of his play sessions, with the way he interacted with the toy, the space involved during his play, and his teacher.

J. has severe visual impairment from birth and also a slight problem with his legs, which prevented him from being freely mobile in the session. He did not yet make use of language, although he understood what was told him. He did not like touching soft objects, but he made good use of his hands in exploring and manipulating other objects. He made use of his residual vision, and was interested in and concentrated on his activities. His second play session took place four months later, the week before the Easter break, as he was ill and away during the second week of study. Unfortunately he was not feeling well in his second play session and did not engage in play.

R. is severely visually impaired from birth, and very reluctant to handle things. He was all the same independently mobile with the use of his residual vision, and was curious about ongoing events. He tended to poke his eyes but this stopped when he was occupied with an activity. His first reaction was to refuse when offered an object or to do an activity, but this was probably a self-protective reaction, and he would co-operate when he felt secure (which he did with his teacher). He liked small cars very much, as he could hold them in one hand and roll them. Therefore he was more interested in stimulating objects with different feels that he could take apart and explore closely.

M. has been totally blind from birth and was the most reluctant to play in her first session. Her two play sessions took place four months apart. During the time she had her first play session, she was having mobility training and was learning to walk by herself. She always had her favourite toy (a snake) in her hand, and did not talk but babbled at that time. In four months she had made progress: she could walk alone, did not need her transitional toy with her anymore and therefore had both hands free in her interaction with objects. She was feeling more secure in an environment with strangers, she was attentive to ongoing events, and she could now talk, make comments, ask questions and express enjoyment. This made a difference in her interaction with Zog as well: she was more explorative, inquisitive, co-operative and showed interest, as her teacher guided her around the features and activities.

Introduction of the Toy to the Child

There always was a teacher or member of staff involved in the play sessions with a child. But the play behaviour of the children depended on how their interaction with the toy was guided. All the children's second play sessions took place with the same teacher. The presence of an adult the child knows, makes the child feel secure. An adult who knows the child and his/her interests contributes more to a play session, keeping the interest of the child engaged in the toy and encouraging the child into activities which might otherwise not be ventured. Wording used by the teacher is also important. As children have partial sight or are totally blind, the wording used by the teacher stimulates the child primarily, before the toy or its features.

The Toy and its Features

The main activities expected to be observed were, exploring the face, exploring the legs, displacing-replacing objects, pulling the tail, getting on and off the toy. All the children did most of these activities. By trying out these activities on different parts, the children who were relatively mobile had an idea of the whole of the toy. The initial contact the children had with the toy was, with the face with its textured features. This helped them understand and perhaps represent in their mind a toy 'doggie' as a personified companion.

The most enjoyed activity was pulling the tail and feeling the vibration in return. Once the tail was tried, the children were more open in trying out other activity possibilities offered by the toy and introduced by the teacher. The two children who were relatively less mobile were supported by their teacher in moving around. Or else they were sat in front of an activity (the face, a leg) and focused on it. It can be said that the toy was explored as a whole, or the activity that was focused on, was investigated as to all its possibilities (such as exploring an object individually and in its location on the leg). This began with the prompting of the teacher, and from then on the children continued to explore on their own.

Spatial Involvement

In their first sessions, the independently mobile children (C. and R.) searched the space for other play possibilities, rather than getting to know the toy. In their second sessions, the teacher engaged them into activities related to the toy, and both children were active within the close space of Zog. Their search into the space of the room was related to their play with Zog (such as C.'s 'putting out a fire' in a distant corner, and his 'going to the seaside' in another corner by 'riding' Zog). R. also used high and low areas in his play. He reached and leaned over the body to examine it, and he bent down low to investigate the legs. J. was relatively less mobile, therefore he was engaged in activities in front of the toy, but he was encouraged by his teacher to use the activities in high, medium and low spatial areas in front of him (*high areas:* the face and the bell on the collar by raising arms; *medium areas:* the objects on top of the leg surfaces by extending arms forward; *low areas:* the objects on the bottom of the leg surfaces by bending body low forward and extending arms).

In her first session, M. was not so mobile, and very unwilling to play. She leaned her back on the toy, positioning herself away from it, and waited for someone to take her away. In her second session, M. was co-operative and explorative by herself. She touched the horn and the face, but needed support in positioning herself in front of the activity, also in opening her arms to the sides to place each hand on a sphere. As she was still not totally independent in her movements, her teacher helped her move around, leading her by holding her hand, with the other hand contacting the parts (the head, the body, the tail). M. was not engaged in exploring individual objects. Her play session was guided so as to engage her in actively exploring the whole of the toy by using the space around it. She also climbed on and off the body by herself.

Imaginative Play

It can be said that once the children were familiar with the toy as a whole, they were able to play imaginatively with it, or display behaviour that suggested such play. In his second session C. used the toy as a car, a fire engine and a boat. C., the most active of the children and more imaginative in his play, involved his teacher in his imaginative play as well, by giving her roles to participate. He also used the objects in a creative manner to represent other objects (making the sponge flower a petrol cap, and afterwards, a seashell). At the end of his second session R. said 'Bye bye woof woof' as he left the room. J. played 'pat the dog' in his first session. At her second session, M. sang a song as she held the vibrating tail in her hands.

BEHAVIOURS DISPLAYED DURING THE PLAY SESSIONS

Table 7.9.1. displays the behaviours the children exhibited during both sessions. The less vision children had, the more reluctant they were to contact the toy initially, and the more dependent they were on their teacher for emotional support and encouragement. As they got familiar with the toy, this reluctance ceased, yet, one child (J.) still refused contact with the soft objects. The more mobile the children (C. and R.) were, the more independently they were willing to play, as they could guide themselves around Zog and within the room. C., was also more creative in his play. The more the children (C. and R.) made use of language, the more they seemed to be engaged in imaginative play, as they could represent themselves in different situations with Zog, and describe in the meantime, what they were doing.

If the children were not using language (J. and M.), they expressed themselves vocally, such as babbling, humming to a song, singing, laughing or crying, as a result of contacting with and manipulation of the objects, or trying out the activities with their teacher. Two of the children tended to display self-stimulating behaviour (R. was rubbing and poking his eye; M. was rocking to and fro, stamping and babbling to herself). R.'s behaviour seemed to be triggered when encountering a novel object and with the subsequent use of the object. M.'s self-stimulating behaviour was also triggered with similar reasons. In the first session it was related to the stress of encountering a novel object and feeling insecure without her teacher, in the second session it was related to pleasure gained from the vibrating tail and was as an accompaniment to her singing.

Table 7.9.1. The Behaviours that the Children Displayed during the Sessions

	(M.) Totally blind ***Less mobile***		***(R.) Severely visually impaired*** ***Mobile***		***(J.) Partially sighted*** ***Less mobile***		***(C.) Partially sighted (best vision)*** ***Mobile***	
	1ST Session	2ND Session	1ST Session	2ND Session	1ST Session	2ND Session	1ST Session	2ND Session
Use of language	X	√	√	√	X	X	√	√
A. C/M of objects/ features	X	√	X	√	√	√	√	√
B. C/M of toy as a whole	X	√	√	X	√	X	√	√
C. Avoiding C/M	√	X	X	X	√	√	X	X
D. Social with teacher	X	√	√	√	√	X	√	√
E. Imaginative play	X	X	√	X	√	X	X	√
F. Repetitive / inappropriate play	X	X	X	X	X	X	X	X
G. Self-stimulating behaviour	√	√	X	√	X	X	X	X

C/M: Contact/Manipulation

INTERPRETING THE OBSERVATIONS

When the interactions of the children with the toy are considered, the following relationships appear:

The Child-Object Relationship

As the children began their first session, they had an initial contact of their own choice with the toy (*Table 7.9.2.*). This contact was also of a coincidental nature, depending on where the children stopped

Figure 7.9.1. M.'s initial contact with the horn.

as they came in the room, and on the level of curiosity this novel object invoked. This initial contact defined a relationship between the object and the child and encouraged the child to begin to explore the properties of the object. This was the first stage of play in the first sessions, whether the object explored was the face of the toy, the tail, or one of the objects located on a leg (*Figure 7.9.1.*).

Table 7.9.2. The Objects of Initial Contact

	1st session	**2nd session**
C.	The tail	The tail, the star, flowers, letters
J.	The face, the bell, the rectangle	-
R.	The body (the seat), the musical device	The tail, letters, the star, the square
M.	The body (not in an explorative manner)	The horns, the face, the fabric cube, the tail

The Child-Object-Space Relationship

Once the children were familiar with their object of initial contact, they searched for new object possibilities (*Table 7.9.3.*), searching the space defined around Zog and locating novel objects or features on it. This relationship took place as:

- being active spatially around and/or on the toy to understand how it is (*Figure 7.9.2.*);
- displacing an object, and replacing it in its location;
- searching for a familiar object on and/or around Zog (*Figure 7.9.3.*); and
- searching for a novel object on and/or around Zog.

Figure 7.9.2. M. sits on Zog and touches the head, which she had observed facing it earlier on.

This relationship required investigation of the toy with spatial search strategies, such as coming into contact with the toy with one hand, while going around it; positioning oneself to remember where the object was; and using the features to help position oneself and thus locate the object searched for.

Figure 7.9.3. 'This is the head, this is the body and this is the tail.'

Table 7.9.3. Spatial Activities on and/or around Zog

	1st session	2nd session
C.	Climbing on Moving away to look in stacked boxes Exploring face	Climbing on Exploring face Going to tail Using space of room to incorporate into play
J.	Replacing the rectangle, displacing it again Exploring high, medium and low areas in front of him (the face, collar and front legs)	Touching the features of the face
R.	Bending over body to observe Moving away to find cars Bending down to find out where the music comes from	Moving around Zog Discovering the tail Coming across the star and letters
M.	Positioning herself away from Zog	Touching horns Holding both spheres opening arms apart and positioning in front of the head Moving around Zog Touching Zog with hand as moving Climbing on, getting off Standing up by supporting herself with body Exploring features Discovering the tail

The Child-Object-Teacher Relationship

This relationship was what essentially defined the children's play behaviours (*Table 7.9.4*). Without the presence of a teacher who knew the children, their interests and their abilities, play did not take place.

Table 7.9.4. The Teacher's Involvement in the Play Sessions

	1st session	2nd session
C.	(Teacher not available, another member of staff in session) -	(Teacher in session) Encouragement into exploration Exploring features together Support to help concentrate on activity Co-operation Imaginative play
J.	(Teacher in session) Encouragement into exploration Information on features and objects Support for moving around toy Singing and 'patting the dog'	(Teacher in session) Encouragement into exploration Emotional support
R.	(Teacher in session) Encouragement into exploration Information on features and objects Co-operation Support to help concentrate on activity	(Teacher in session) Encouragement into exploration and further interaction Spatially more active around Zog Co-operation Information on features and objects
M.	(Teacher not available, the same member of staff as before in session) -	(Teacher in session) Support for mobility Encouragement into contact and exploration Making aware of existence of objects Information on features and objects Co-operation Emotional support

The teacher was:

- the liason between the object and the child, making the child aware of the presence of the object, and of his/her action that causes a reaction from the toy;
- the supplier of information (what the toy is, which object the child is contacting, what the object does);
- the encouraging factor ('Shall we find out what it does?' 'Would you help me do it?'), and the role model (*Figure 7.9.4.*);
- the factor helping the child to focus on an activity and concentrate;
- the co-operative playmate joining in an activity or helping the child complete it (*Figure 7.9.5.*);
- the playmate for the child wanting a companion for social or imaginative play; and
- the emotional support for a child in need of affection, security and encouragement.

Figure 7.9.4. The teacher shows M. how to pull the tail, then M. pulls it by herself.

OBTAINING OPINIONS FROM INTERESTED PARTIES

Opinions of a Parent

E.'s mother, who comes in once a week with her daughter to the school. E. is blind from birth.

The parent of a totally blind child was asked her opinion on the toy. To understand the toy better she sat on the floor, observing all the parts, and feeling the features and the objects. She also felt the face, body, horns and tail. She approved of the dots on the basic shape objects indicating corners. She also liked the vibrating tail. She found the extensions on the corners of the stars conceptually interesting, as they suggest 'sparkle', but found them too hard and sharp for children like E. She also approved of the idea of tracking from shape to song, but found the tracking lines complicated. They were not continuous and were made of different textures. She suggested that a continuous, single texture line could be used to track to them, and the same texture as the tracking line should be on the song button for the child to relate. The parent wanted to make sure the toy was safe enough, as children are going to sit on it. She asked about the eyes, and was informed that the black frame on one is to give the child a discriminative idea of left and right. She suggested the same could be done on the horns. The mother discovered that the legs could be used individually, as separate toys. She also said each object could be used as a separate toy, which is one of the design objectives.

Figure 7.9.5. The teacher helps M. place the sponge flower in its socket.

Opinions of a Teacher

Maggie B. from the school.

Maggie found the toy imaginative and thought-out in detail. She approved of the way soft and hard objects are placed together on the legs, so that the child can come across them. Blind children do not like soft objects, a reaction which Maggie believes is an instinctive self-protection mechanism against encounters with live things in nature. Hard objects, on the other hand, immediately convey the haptic sense of their hard, consistent, definite properties. She remarked that blind children enjoy more, objects disappearing into toys, as the child witnesses an immediate feedback as to the activity just carried out. To illustrate what Maggie says, another teacher showed a posting toy where the falling object makes a throaty noise as it slides down the tube. Another posting 'feed the animals' toy makes the sound of the animals it has, as the plastic food slides down their throat. Maggie also commented on the materials attaching the objects to the legs. The magnet needed to be stronger, as children can make them fall with accidental gestures. And the velcro needed to be weaker, as the one used was very strong and the child (R.) who tried pulling the square off its socket, had difficulty in doing so.

CONCLUSORY DISCUSSIONS ON THE OBSERVATION OF TOY TRIAL

As a toy specially designed for blind and visually impaired children, it may be surmised that, Zog may encourage behaviours that were defined in the hypothesis of the field test at the beginning of the study, in *Section 7.8.*. The listed behaviours have been observed during the play sessions in the form of the three types of relationships: *Child-Object, Child-Object-Space, and Child-Object-Teacher.* Overall, the children did show interest in Zog as a toy to be explored, spent time in trying out some of the activities, and were spatially engaged around it. The toy acted as an object of social interaction between the child and the teacher, and therefore could be used as a learning toy.

It can be said that the toy was played with in the ways it was intended: exploring the face, exploring and riding on the body, exploring the tail, and one or two objects, displacing and replacing them. The features with the most stimulating aspects were played with the most: the tail with its vibration, the sponge flower with its squeak, the star with its flickering lights, the basic hard objects (the square and the rectangle), the leg which had the musical device, and the leg which had the letters speaking out their names. None of the children smelled the sponge flowers. The activities that did not evoke immediate interest and were not played with, were those that were on the side surfaces of the legs that remained hidden under Zog's body. The children tended to contact those objects that were immediately under Zog's face after they explored it, or those immediately under the tail after it was played with. They did not use the space around Zog to search for objects on the legs, but used that space to understand and play with Zog's main features, or to climb on and off it.

Two sessions were insufficient to observe whether the children displayed any behaviour that suggested they made spatial connections (or were not interested in doing so) between the objects and their locations on the legs, by using the tactile cues on the leg surfaces that were placed to refer to the objects that belong there (such as frames, dots indicating the number of petals, and tracking lines leading from shapes to the musical device). These details of the toy could be assessed through children playing with each leg individually with its related objects, and in play sessions over a longer period.

The children did show play behaviour that suggested they involved imagination, such as personification of the toy (patting the head, saying 'bye bye'), or using it and its features as something else. The use of imagination Zog evokes could be investigated further by more sessions with the same children; as the children become more familiar, they may search for creative ways of playing with it or give new roles to its features. The use of imagination can also be observed through play sessions with more than one child around the toy, where the children may play co-operatively or display social pretend play.

The participating children were all around 3 years of age, which is just about when children are considered to be within pre-school age range. The design features of the toy were more suitable to children of 4-6 years. The study indicated that the toy was big for the participating children, revealing this particularly when the children climbed on and off the toy, sat on it with legs apart, and extended arms across the horns. The study may also be done with children of the upper pre-school age range, not only for ergonomic reasons, but also to assess the toy in cognitive terms, and in the interest it evokes with the play opportunities offered. Depending on the results of such a study, some of the activities may be further complicated, or else, the features of the toy may be adapted to physically better suit younger pre-school children.

The conclusory remarks and discussion on the observation during field testing, reveal the need to review certain design decisions. The need arises mainly from:

- observed physical relationships between child and toy components;
- observed cognitive relationships between child and toy components; and
- opinions obtained.

OUTPUT: DECISIONS ON REVISION

7.10. REVISION ON THE DESIGN

INPUT: DESIGN SPECIFICATIONS, FINAL CONCEPT, WORKING MODEL AND DECISIONS ON REVISION

Revision on the toy may take place in the following aspects:

- Design features in general in terms of:
  - ergonomic properties,
  - safety,

- suitability to the needs and interests of the user group,
- stimulating aspects,
- appeal,
- understandability of layout,
- manipulability of features and details, and
- manufacturing quality.

- The pre-school activities offered in terms of:
  - play opportunities, and
  - learning opportunities.

OUTPUT: DECISIONS ON MODIFICATION

7.11. SUGGESTED MODIFICATIONS TO THE DESIGN

INPUT: DESIGN SPECIFICATIONS, FINAL CONCEPT, WORKING MODEL AND DECISIONS ON MODIFICATION

Due to the limits of the production techniques and of the field test, certain features of the toy are difficult to assess as to their nature and play value. Some of the play activities related to the legs, their layout and detailing has to be reconsidered, product safety has to be reassured, and the field test repeated in more pedagogic terms. All the same, due to the conceptual nature of the project, certain suggestions will be made as modifications, and as further ideas that emerged as a result of the insight gained during the observed play sessions.

1. Initially it was thought that, having the dog stable would be a good idea to provide safety. But, inspired by C. who sat on Zog and tried to make himself wobble up and down, the body of Zog could be made bouncy, on a system of springs. This could keep the legs stable, but make the body move up and down (*Figure 7.10.1.*). In this case, the design solution should not trap fingers of children exploring the legs while a friend is bouncing. The system should also be lockable to stabilise it when necessary. The bouncing activity may give some children an enjoyable bodily sensation that they would otherwise gain from self-stimulating behaviour such as rocking. This behaviour may thus be kept under control, if channelled on to the toy.

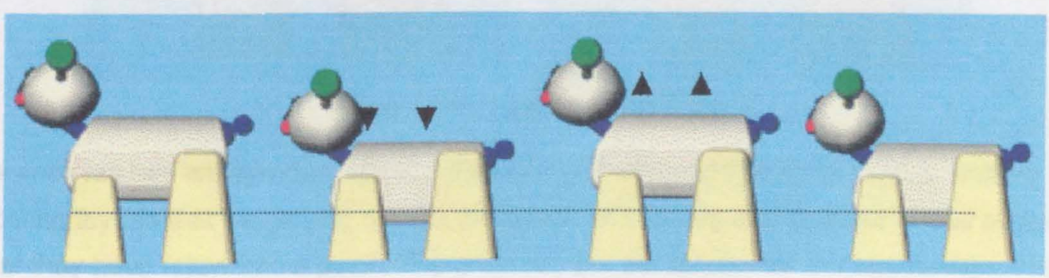


Figure 7.10.1. The body bouncing on springs.

2. Zog defines certain positions in space, such as front (the head), back (the tail), left and right (with different objects on the sides). Left and right are also defined on Zog's eyes: the one on the left when facing, has a black frame for the child to distinguish from the one on the right. Yet, the symmetry of the toy can be slightly more interfered with, to give the child the notion of laterality. It is suggested that the horns which are identical in shape, size and texture could be given a difference in feel. The sphere on the right horn when facing, can be made textured so that when a child holds both spheres at the same time positioned in front of Zog, there is a difference between the left and the right (*Figure 7.10.2.*). When the child sits on Zog and holds onto the spheres again, the sensation will swap hands. The child may thus make sense of changing position in space, and how this affects his/her position relative to other stable objects in this space.

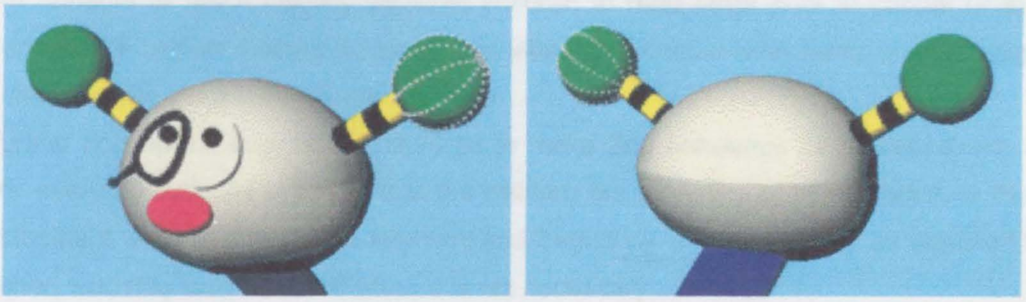


Figure 7.10.2. Texture on the right horn.

3. Children who have residual vision may look closely at objects for some time. This has been the case with R. whose first contact with Zog was with its body, which was closely examined. The body is presently white, like the head, to emphasise the facial features, horns, tail and the legs. But it could also be used to display certain patterns to visually stimulate a child (*Figure 7.10.3.*). These patterns can be on wraps that could be dressed over the body, changed for different patterns, or taken off to reveal the white body when necessary.

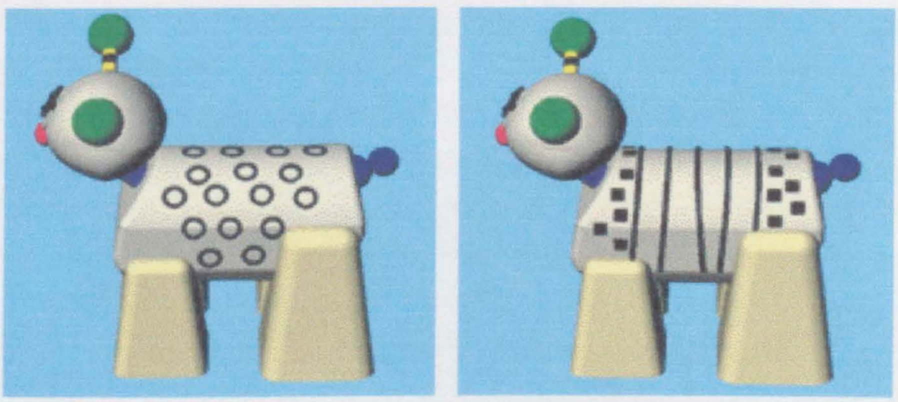


Figure 7.10.3. Patterns on the body.

4. As each leg has an individual identity, they can be rearranged so as to change one leg into a posting toy, so that the posted objects disappear into the leg and give out stimuli suggesting that they have fallen into a place. The child can put his hands into the leg through a hole or open a lid to retrieve the objects. These would provide different activities involving the use of hands in novel ways (putting in, pulling out, opening, shutting).

5. Smell as a stimulus did not attract attention, as it came from soft objects, which the children preferred not handling. Besides, the intensity of the aroma faded in time. The smell factor could be incorporated into the harder objects, which the children are sure to handle and manipulate, thus discovering it as a property. The smell-producing material may be put in the objects, and through thin holes of one of the surfaces, the child may sense the smell.
6. The star forms will have their edges and corners chamferred further.
7. Some of the tracking lines may be made continuous with one single texture as suggested by the parent, but the other discontinuous combination track lines may remain. When the child is experienced in tracking a continuous line, he/she may then progress to using the combination lines as a cue to their directionality and their suggesting which shape they lead to.
8. The letters on the legs of Zog are in capital. A final issue that has been raised is whether it is more suitable to teach visually impaired children to read large print in capital or in small letters. As the regular method is using small letters, the capital letter forms on Zog's legs may be changed into small letter forms.
9. A further conceptual suggestion would be to make Zog announce its presence with a mild 'bark' every 30 seconds or so, so that the children are reminded of its presence, or that they can locate it within a space. The intensity and frequency of the bark may be adjusted by the teacher, who may also turn it off when it is not necessary.

OUTPUT: REFINED AND FINALISED DESIGN DECISIONS

8. CONCLUSION:

The hypothesis of this study has been that, due to the social, economic, and ecologic responsibilities it carries, design should be conducted within a guided process for efficient results, that will best suit the system into which the output is to be integrated. The application of methods, as techniques and procedures for guidance for the design process, requires careful selection, as the design process today involves complicated issues on large scale, that rapidly change with time, needs, and progress in technological, social, and environmental terms. A primary conclusion drawn from the thesis is that, design methods used in separate phases of the process may fragment the process and remain insufficient in uniting the preceding and following phases of the design processes that may need to be tackled in integrity for novel concepts. Another aspect driven forth is that, once the problem is posed, it should be investigated with intense research for an understanding of the situation, and particularly, for correct interpretation of the research findings to be integrated into the design process and consequently, reflected into the solution to be offered. Still another corollary is that, a design problem requires a multidisciplinary approach that supports the research, and its interpretation and integration into the process. These points have brought forth the necessity of a design model, rather than the selection of methodology.

8.1. DISCUSSION OF THE PROPOSED DESIGN PROCESS CORE AND THE APPLIED DESIGN PROCESS MODEL IN THE LIGHT OF THE LITERATURE REVIEW ON DESIGN METHODS AND MODELS

The literature review and its interpretation on phase models as guidelines that organise the design process into steps has revealed that, design models used in engineering are problem-oriented, therefore limiting designers in using their creative and intuitive approach towards solution-oriented design tasks. Solution-oriented models on the other hand, rely on random creative activity, and systematic elimination of alternatives, instead of activating creativity, guided by a deep understanding of the problem and research on the user group and situation. In the context of this thesis work, a design process core was devised to accommodate an approach allowing the creative activity of the designer, yet, controlling the random creativity that may diverge the design activity towards unnecessary expense of time and resource, and stressing the importance of problem identification and definition, and inclusion of the user group, towards a product of valid social consequences. A design process core was thus devised as a structural basis, on which to found all design processes (*Figure 8.1.*), with particular emphasis given on problem identification, novel concept generation, integration of research findings into the process, and frequent involvement of the user group. The novel approach that this core brings is, to allow models to be built on this foundation for diverse fields of design. The model may incorporate not only the design-related activities, but also research, marketing, production and business related issues, depending on the scale of the project. The core and core-based models may be used by individual designers, as well as by teams working in collaboration.

In this case, the model based on the core was devised with the considerations that the process would be carried out by an individual, who would conduct an extensive amount of research in order to define the problem area, and to integrate the research findings into the process, also including experiences with the user group throughout, though excluding business and production related issues. The output of the design process that follows a model based on this core, is not only a product, but also the model itself that can set example to following design problems of similar nature. The model offers a systematic guideline to base actions on, and is not a set of instructions to be applied one after the other. It may act as a foundation on which diverse activities, strategies, and even use of methods can be based. Apart from the outputs as a product and a model, are generated knowledge, that is related to the design activity and to the process carried out. The model particularly aims at generating knowledge related to the user group, through the intense research it encourages throughout the process, the frequent involvement of the user group in the process, and the field testing and repeated design activity that the core envisages.

The proposed design model thus aims to lead towards the investigation, interpretation, questioning, creation and generation of new ideas and knowledge at each stage. Each stage responds to information input and output from other stages. Each step in each stage is interrelated as parts of a whole, towards attaining integrity in the process, as a system of information. The representation of the process thus gains importance; as it conveys information transformation, it has to be transparent, and speak a language common to all disciplines that contribute, making a meaningful distribution of the generated knowledge, possible.

In developing novel concepts relying on intense research to relate the output with the system into which it will be incorporated, such a guideline built on the core has to be systematic, in order to make the process accessible and understandable by all contributing parties, and to be able to build up an output that clearly conveys all the multidicsiplinary input that is invested. With this conclusive argument drawn from the literature review and discussions, the design model devised became a systematic guideline organising the design process into a structure of sequential stages.

The model is thus based on the understanding that the design process has to accommodate activities at each stage, targeting the production of the best decisions as output of each stage. This means that the stages must be viewed in a flexible sense, allowing iteration within each stage for re-evaluation over and over. The model must also allow the selection and application of suitable design methods to be applied throughout the process, if found necessary.

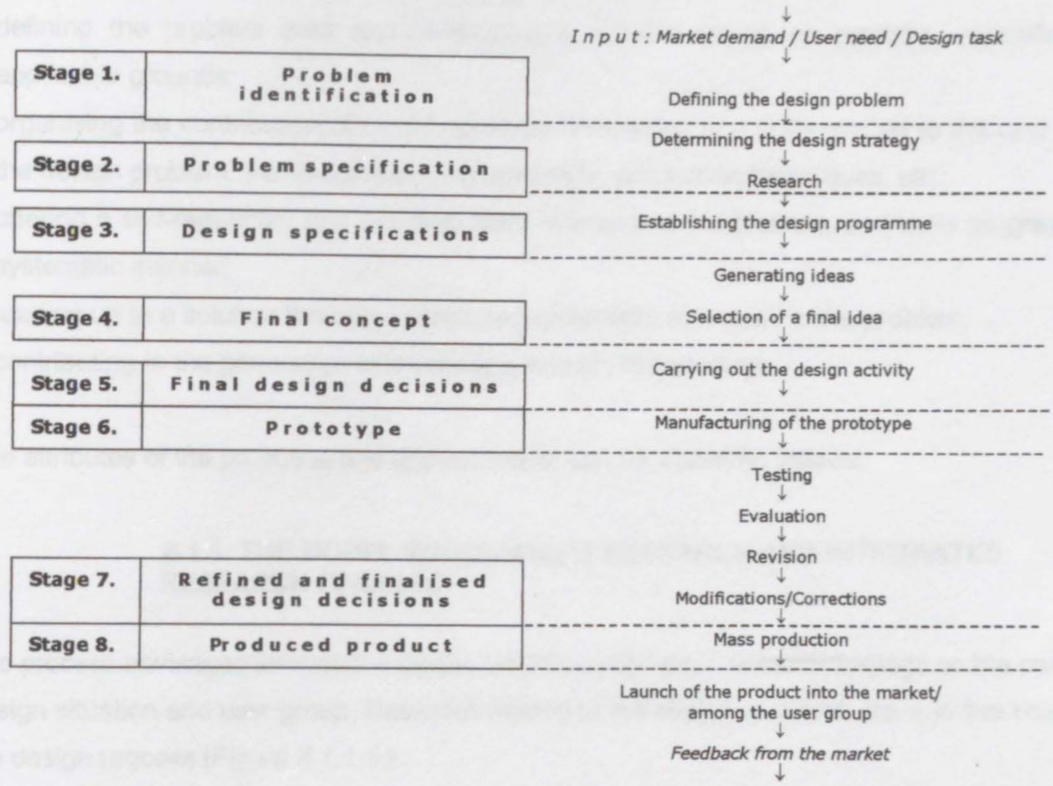


Figure 8.1. The design process core in relation to the activities of the design process.

The model though, does not fragment the process into the strict thresholds of *analysis-synthesis-evaluation*, but extends them into the process. The methods and models discussed in *Chapters 2., 3.,* and *4.*, relied upon this segmentation towards determining the timing of the methods to be employed and decisions to be made. Within design tasks that require their own problem-identification, a novel concept and field testing, towards reconsidering the process and refining the design output, it is inevitable that in the design process analysis, synthesis and evaluation lose their thresholds and extend into the process, interacting with each other, regulating the information handled, and decisions made. In this sense, the role of the designer is reconsidered as not only the person who undertakes the creative act of designing, but also as possessing the knowledge and ability for using the core to suggest own model and follow through its realisation. The suggested core therefore envisages the designer as the person who is the orchestrator of the activities carried out, and strategies and methods used, while collaborating with other disciplines.

As a conclusion, the proposed design process core offered a basis onto which could be built a process model according to the requirements of the design task. The design task, in this case, of an educational toy for blind and visually impaired pre-school children, required from the design process model, the following issues to be responded to:

1. intense research, its interpretation and integration into the process and into the output of the process;

2. integrating the user in the entire process, as study of the user group, consulting the user group, during the actual design activity and during field testing;
3. defining the problem area and developing a novel concept, on realistic, controlled and applicable grounds;
4. organising the contribution of multidisciplinary knowledge and skills related to the user group, the design problem, the design situation, materials, production techniques, etc.;
5. offering a self-regulatory and self-evaluative structure to the process, and to its progress, in a systematic manner;
6. leading up to a solution through a controlled systematic approach to the problem;
7. contributing to the generation of knowledge through this process.

The attributes of the proposed and applied model can be stated as follows:

8.1.1. THE MODEL ENCOURAGES RESEARCH AND INTEGRATES RESEARCH FINDINGS

The process envisaged through the model, relied heavily upon research findings on the particular design situation and user group. Research related to *the design task* took place in five phases of the design process (*Figure 8.1.1.1.*):

- Phase 1, during *problem identification*, revealed in what direction the problems lay;
- Phase 2, during *problem specification*, in deciding upon the direction to be taken;
- Phase 3, during *design specifications*, in determining the design features that could respond to the encountered problems;
- Phase 4, contributing to the generation and evaluation of a *final concept*;
- Phase 5, during which the methodology of the *field testing* of the working model was determined, and the way the study findings contributed to the determination of the *refined and finalised design decisions*.

Research related to *the activity of design* took place in four phases of the design process (*Figure 8.1.1.1.*).

- Phase 1, during the determination of *design specifications*, about how the design activity should be carried out, and how the design-related decisions should be selected and applied;
- Phase 2, during the determination of the *final design decisions*, in order to decide upon the materials to be used, the production techniques to be employed, how the final design is to be represented, etc;
- Phase 3, during the making of the *working model*, on issues such as materials, workshop techniques, and construction techniques; and
- Phase 4, on how the study findings could be reflected on the *refined and finalised design decisions*.

Research in both veins had to be integrated and could not be considered separately and individually, in order to maintain integrity in the process.

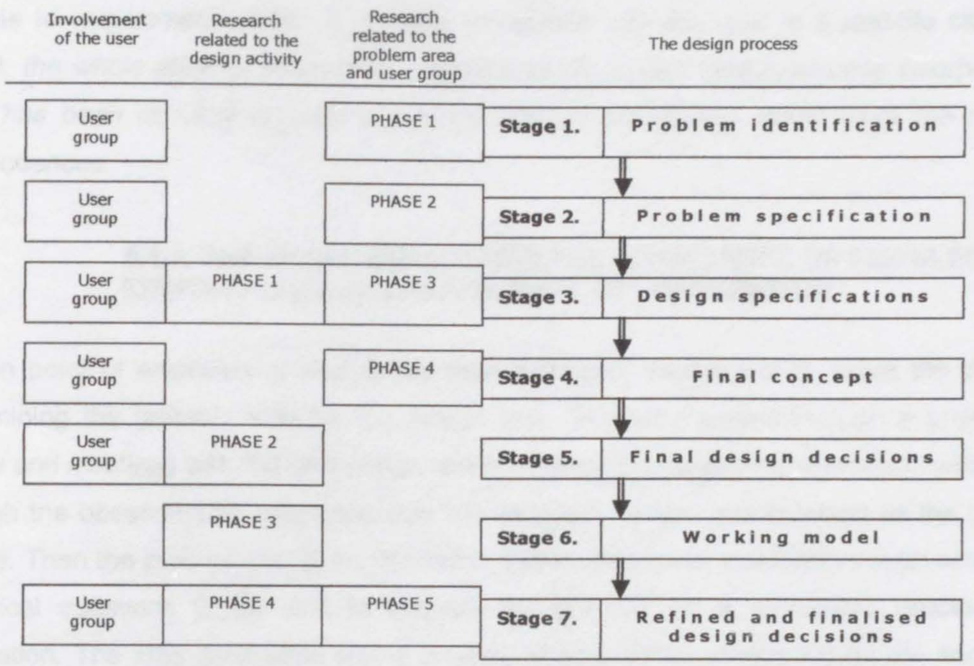


Figure 8.1.1.1. The phases of contribution of research findings and the involvement of the user group in the design process

8.1.2. THE USER IS INTEGRATED INTO THE MODEL AS A STRUCTURING AND CHECKING AGENT

A main aim of this particular model presented, was to integrate the user group into as many stages of the design process as required (*Figure 8.1.1.1*):

- In the *problem identification* and *problem specification* stages; to define the user group with its abilities, needs, the present situation that awaits different design solutions, and the expected effects of the product.
- In the *design specifications*; to obtain information on the user group's development and play skills, related human factors data, and review on past studies concerning similar cases; to determine limitations and constraints; to assure user safety with related regulations, and to relate the capabilities of the user group to the requirements of the product to assure a balance within the user-product relationship.
- In the *final concept*; to assess the suitability of the idea in conceptual terms, with the problematic situation in hand;
- In the *final design decisions*; to offer a physically and cognitively suitable product and to obtain feedback from samples of users as the design is developed in 3-D form.
- In testing the *working model*; to ensure safety through safety testing, and to be able to evaluate the user reaction and interest through field-testing.
- In determining the *refined and finalised design decisions*, to correct or modify conceptual or design decisions after the working model is tested; to refine the design and better suit the requirements and needs of the user group.

The reason for involving the user frequently in the design process was to ensure an outcome suitable to requirements, when it is finally in relation with the user in a real-life situation. To repeat, *the whole effort of conducting a systematically guided design process incorporating the user, has been directed towards a relevant product output that would have the right social consequences.*

8.1.3. THE MODEL EMPHASISES THE IMPORTANCE OF PROBLEM IDENTIFICATION AND NOVEL CONCEPT GENERATION

A main point of emphasis related to the design process model was to assist the designer in determining the problem area for the design task. This was guided through a brief literature review and meetings with the user group, where a frequently encountered problem was identified through the observations, supported with the literature review, and selected as the problem to handle. Then the problem had to be defined in further detail and specified through sequences of analytical questions to be able to prepare the grounds for a systematic process of idea generation. The idea generation was a process of sequences of *drawing on the knowledge of research on the user behaviour-visit to the user group-skethcing of an idea* until arriving on the fact that *the final concept had to address children with diverse skills and needs, and not only on one aspect of their need or interest.* Therefore, the selection of the final concept took place as not the elimination of the ideas until one final remains, but as the selection of some of the ideas to be combined in a concept founded on a *first principle* that emerged as a result of this creative process.

It can be said that, the methods of creativity and decision-making envisaged to be used in the draft design strategy were used to some extent, but not as methodically, particularly in the decision-making phase. The selected ideas to be used in the final concept were not determined systematically through matrices or charts as envisaged, but rather with decisions related to the play interest the children showed, the requirements of the first principles and the suitability of the generated ideas to these principles. The ideas, determined on the needs encountered, did not rely on associations or speculations; therefore excessive ideas that had to be systematically eliminated through decision-making methods, were not generated in the first place.

8.1.4. THE MODEL INCORPORATES MULTIDISCIPLINARY KNOWLEDGE AND SKILLS

The model served as a guideline in organising the multidisciplinary knowledge and skills that had to be drawn in. To the design process, different disciplines contributed, at different stages, with differing levels. As the thesis is not a collaborative work, the model and its application have been carried out by the author only, who has envisaged the incorporation of the necessary knowledge and skills from diverse disciplines related to the design task. The following chart shows on the right hand side the disciplines that were incorporated at each stage of the design process:

↓
Input: **DESIGN TASK**

1. Problem Definition

Determination of the user group:
age, location, condition, assisting persons.
Determination of the present behaviour/situation
Determination of the abilities of the user group
Determination of the needs of the user group
(teachers and parents included in the user group)
Requirements from the product:
function, purpose, medium of use, etc.

Pedagogics Educational psychology Developmental psychology

Output: Problem Identification
↓
Input: Problem Identification

2. Determining the Design Strategy
Output: Draft Model for the Design Process

Design theory

↓
Input: Problem Identification and
Draft Model for the Design Process

3. Research

Getting to know the user group through:
observations, interviews, surveys.
Literature review and review on past studies
Product survey
Visits to:
schools and homes, to the experts of the field, to designers, to the industry.

Design theory Design practice Behavioural psychology

Output: Problem Specification
↓
Input: Problem Specification

4. Establishing Design Specifications towards a Programme

Determination of the design aspects:
cognitive aspects for understandability;
physical aspects for usability;
attracting qualities;
stimulating effects.
Stating the limitations and constraints:
standards and safety regulations;
time and economic limitations;
limitations in resources and manufacturing possibilities.

Design theory and practice Behavioural psychology Educational psychology Law and regulations Manufacturing engineering Materials engineering

Output: Design Specifications
↓
Input: Design Specifications

5.Creation of the Concept

Generating ideas through:
discussions, sketching, rough models, critiques.
Presenting ideas to the user group for immediate feedback
Selecting one alternative that suits most of the design specifications

Design practice Educational psychology Model making

Output: The Final Design Concept
↓
Input: The Final Design Concept

6. Designing

Refining the design concept through:
visual communication techniques
Transferring the design concept into a legible product
Critiques from and discussions with colleagues
Carrying out further necessary research
Selection of materials and production techniques

Design theory Design education Manufacturing engineering Materials engineering Personal insights

Output: The Final Design Decisions

↓

Input: The Final Design Decisions

7. Manufacturing of the Working Model

Output: Working Model

Model making Workshop techniques

↓

Input: Working Model

8. Testing

Safety testing (could not be carried out)
Field testing

Safety regulations Behavioural psychology Clinical psychology

Output: Data Collected from Testing

↓

Input: Working Model +
Data Collected from Testing

9. Evaluation of the Final Design

Evaluating test results and collected data
Interpreting the study
Obtaining opinions

Behavioural psychology Clinical psychology Statistics Educational psychology Developmental psychology Personal insights

Output: Decisions on Revision

↓

Input: Design Specifications, Concept, Working Model, Draft Model of the Design Process + Decisions on Revision

10. Revision

Revising the concept
Revising the design decisions
Revising the production decisions
Revising the design model

Educational psychology Developmental psychology Design theory Design practice

Output: Decisions on Modification

↓

Input: Design Specifications, Concept, Working Model, Draft Model of the Design Process + Decisions on Modification

11. Correction/Modification

Making necessary modifications
Giving explanations and justifications

Design theory Design practice

Output: REFINED AND FINALISED DESIGN DECISIONS

The application of the model once again made apparent the fact that, a multidisciplinary approach is necessary, to obtain unbiased, correctly interpreted, valid research results in all fields of design. Apart from preventing misjudgements and misunderstandings, collaboration between disciplines widens approaches and points of view and provides the opportunity to widespread and share knowledge and skills. This in turn, gives way to further research possibilities by offering findings to be investigated, developed, and applied in real life situations.

8.1.5. THE MODEL IS SYSTEMATICALLY SELF-REGULATORY AND SELF-EVALUATIVE

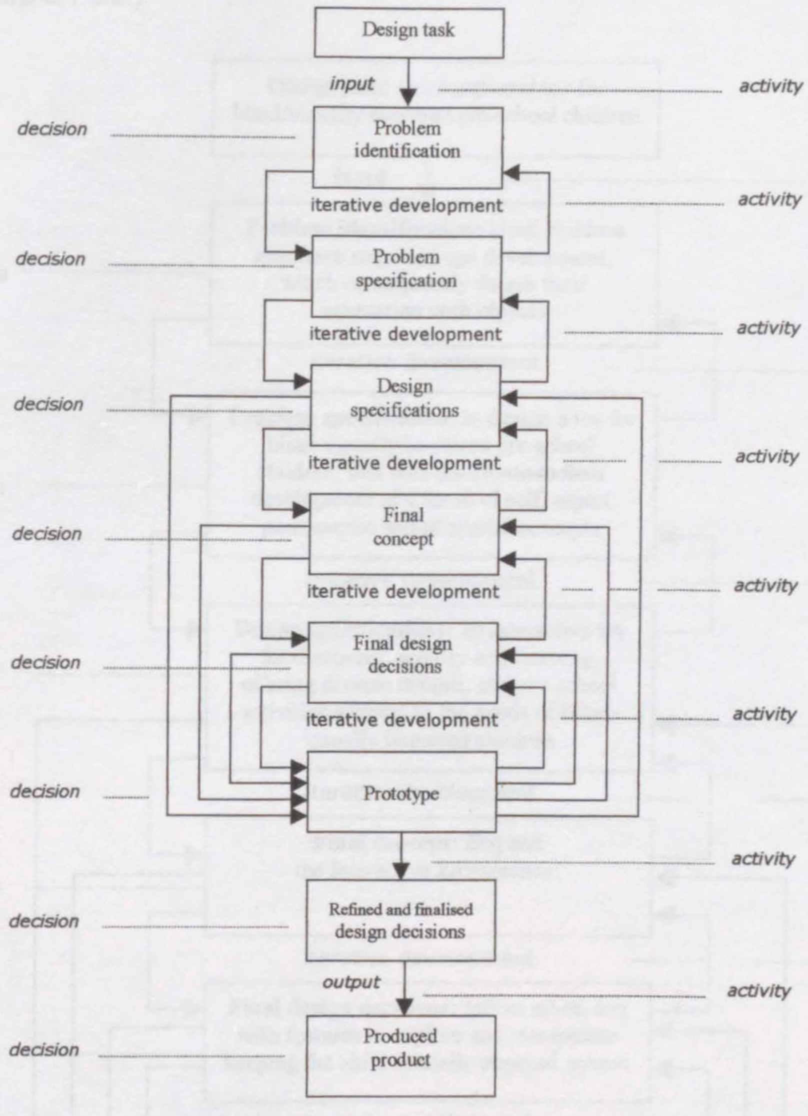


Figure 8.1.5.1. The linear and iterative structure of the skeletal framework.

As can be observed, the outcome of each stage of this model is the input of the following (*Figure 8.1.5.1.*). If there is incompatibility between the output of a stage and the requirements of the input of the next, the decisions and results reveal the need to be reconsidered. The model based on the core hopes to lead towards the investigation, interpretation, questioning and creation of new ideas at each step. This step-by-step constructive nature of the model minimises the risk of decisions that may lead to mistakes. The steps in the stages are determined to assure a certain consciousness of decisions along a linear track, particularly in projects like the one at hand, that search for their own problem identification and a totally novel concept. A cyclic approach on the other hand, may be useful within the steps of each stage of the model, where the outcome has to be rather specific to provide a basis for the next stage. Nevertheless, the model had to be flexible enough to provide the possibility to return to the previous stages, as the design process requires constant checking and backtracking, true to its interactive and self-evaluative nature. Each step and stage is interrelated towards making of the design process a whole, embodying multidisciplinary information, knowledge and skills. As the process progressed, the design concept and solutions added onto themselves and the problems were answered in a systematic manner (*Figure 8.1.5.2.*).

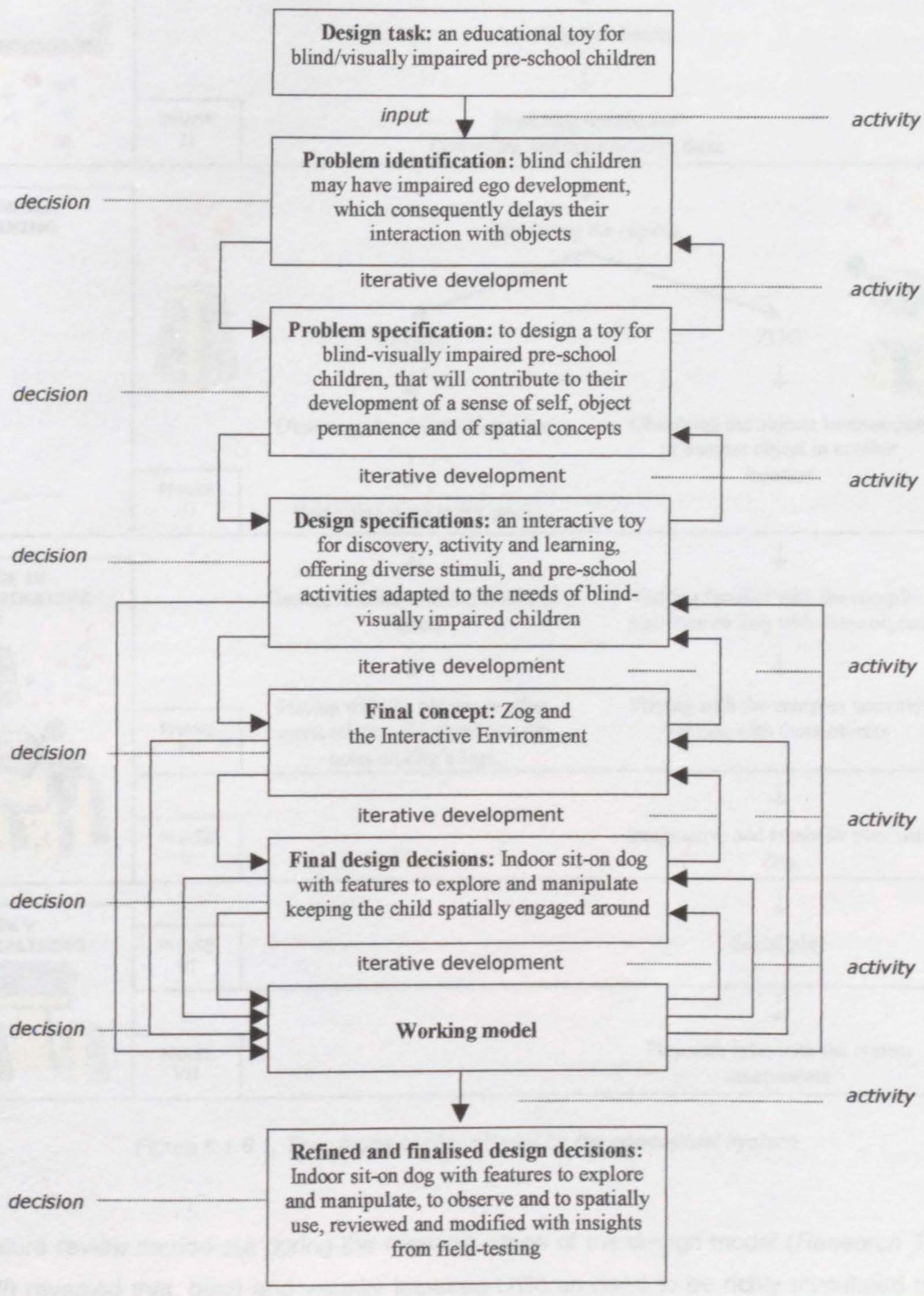


Figure 8.1.5.2. The systematic structure of the core determining the products of the stages of the particular design process developed through the self-evaluative and self-regulatory nature of the model.

8.1.6. THE MODEL SYSTEMATICALLY AND ACCUMULATIVELY LEADS TOWARDS A DESIGN OUTPUT

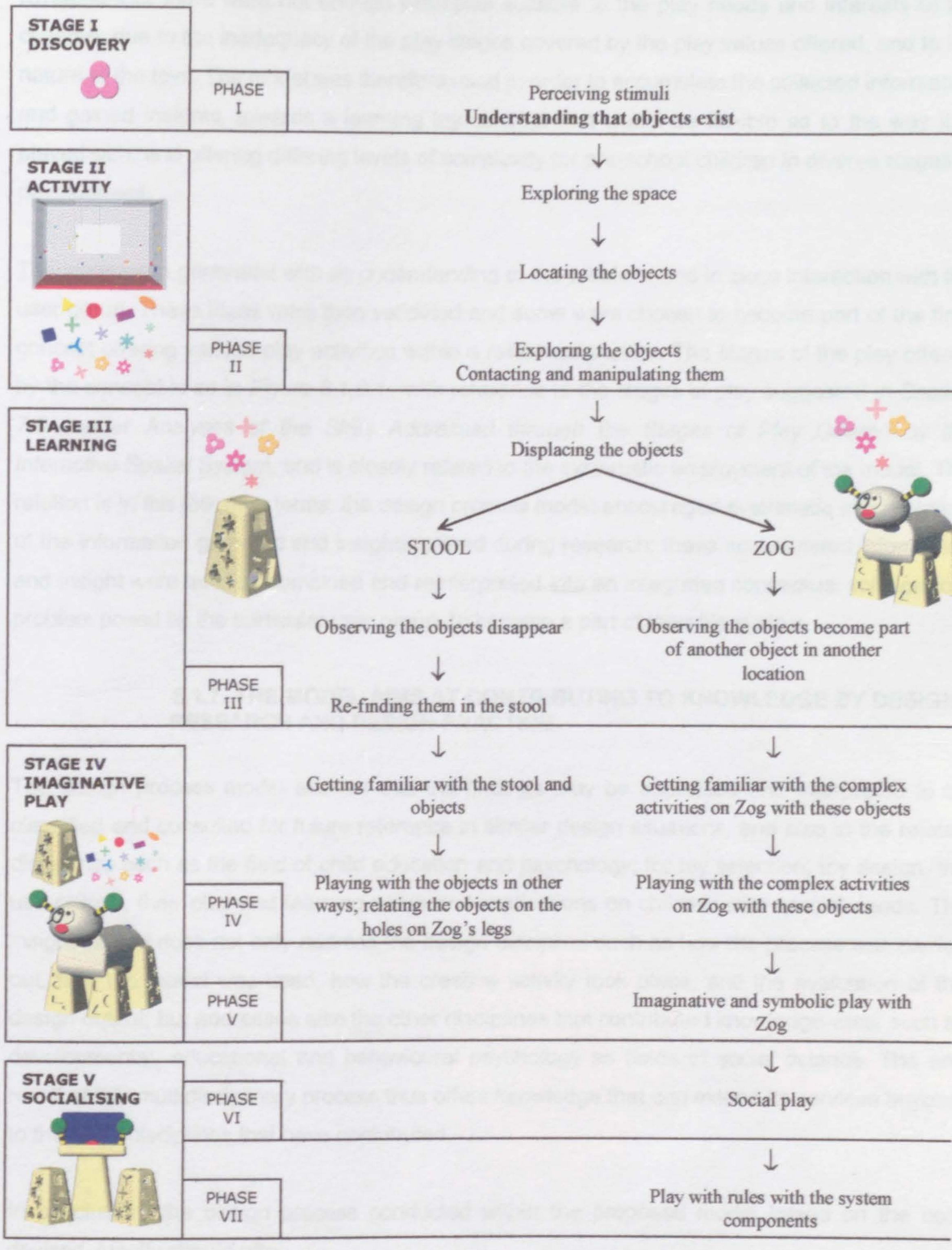


Figure 8.1.6.1. The stages of play offered by the conceptual system.

Literature review carried out during the research stage of the design model (*Research Topics I* and *II*) revealed that, blind and visually impaired children need to be richly stimulated through their environment, and play is the main means of providing such experiences for the children who may be delayed in physical, cognitive and socio-emotional terms. Review on toys in the market and particularly those used by blind and visually impaired children (*Research Topics IV and V*) revealed that there were not enough examples suitable to the play needs and interests of the children, due to the inadequacy of the play stages covered by the play values offered, and to the nature of the toys. The model was therefore used in order to accumulate the collected information and gained insights, towards a learning toy concept that would be flexible as to the way it is played with, and offering differing levels of complexity for pre-school children in diverse stages of development.

The ideas were generated with an understanding of the problem, and in close interaction with the user group. These ideas were then validated and some were chosen to become part of the final concept offering various play activities within a reference system. The stages of the play offered by the concept is as in *Figure 8.1.6.1.*, with reference to the stages of play suggested in *Section 7.5.*, under *Analyses of the Skills Addressed through the Stages of Play Offered by the Interactive Spatial System*, and is closely related to the systematic employment of the model. The relation is in the following terms: the design process model encouraged systematic accumulation of the information gathered and insights gained during research; these accumulated information and insight were later on combined and reinterpreted into an integrated conceptual solution to a problem posed by the particular user group, to become a part of their life system.

8.1.7. THE MODEL AIMS AT CONTRIBUTING TO KNOWLEDGE BY DESIGN RESEARCH AND DESIGN PRACTICE

The design process model allowed that the findings may be appraised and interpreted to be classified and consulted for future reference in similar design situations, and also in the related disciplines such as the field of child education and psychology, for toy selection, toy design, the use of toys, their play and learning value and implications on children with special needs. The insight gained does not only address the design discipline such as how the process was carried out, how the model was used, how the creative activity took place, and the evaluation of the design output; but addresses also the other disciplines that contributed knowledge-wise, such as developmental, educational and behavioural psychology as fields of social science. The end result of this multidisciplinary process thus offers knowledge that can extend its services beyond, to the other disciplines that have contributed.

In conclusion, the design process conducted within the proposed model based on the core devised, ideally should offer:

- A design process model as a tool devised and used for a particular design process; as mentioned in *Sections 8.1.5.*, and *8.1.6.*.
- The possibility of investigating the design model to understand its strengths and weaknesses and to reinterpret it considering different circumstances, in order to suggest improvements for different design situations; as mentioned in *Section 8.1.5.*.

- The possibility of understanding the role of the user in the process and searching for new ways to involve the user where necessary; as mentioned in *Section 8.1.2.*.
- The possibility of understanding and studying the role of the designer in the design process through following his/her actions in the methodology; thus being able to assess the role of individual approaches, subjective value judgements and the input of creativity in the design process; as mentioned in *Section 8.1.4.*, *8.1.5.*, and *8.1.6.*.
- The possibility of using the generated knowledge in different design situations, also of sharing this generated knowledge with other sciences and disciplines for interdisciplinary collaboration; as mentioned *in Sections 8.1.4.*, and *8.1.7.*.
- Acquiring a product developed as the most suitable solution to a design problem within the available circumstances and the limited time span; as mentioned in *Sections 8.1.3.*, and *8.1.6.*.
- The possibility of carrying out research on the uses of this product in its real-life situation and among the actual users; as mentioned in *Sections 8.1.4.*, and *8.1.7.*.

8.2. LIMITATIONS ENCOUNTERED AND SUGGESTIONS FOR FURTHER RESEARCH

There were limitations encountered during the phases of the making of the working model and field testing. As mentioned in *Section 7.4.*, under *Limitations*, and as explained in *Section 7.6.*, under *Designing the Toy System*, the interactive environment could not be constructed and tested, the working model had to be reconsidered as to the material and technique to be employed. Again, as mentioned in *Section 7.8., footnote 8*, the field testing methodology that was devised, could not be employed in entirety, due to the scheduling of the school, and to the young age of the children who had to be supervised during the sessions. The number of the participants, and the amount of the sessions were therefore not totally enough to suggest statistical implications that could be attributed to the population of blind/visually impaired pre-school children as a

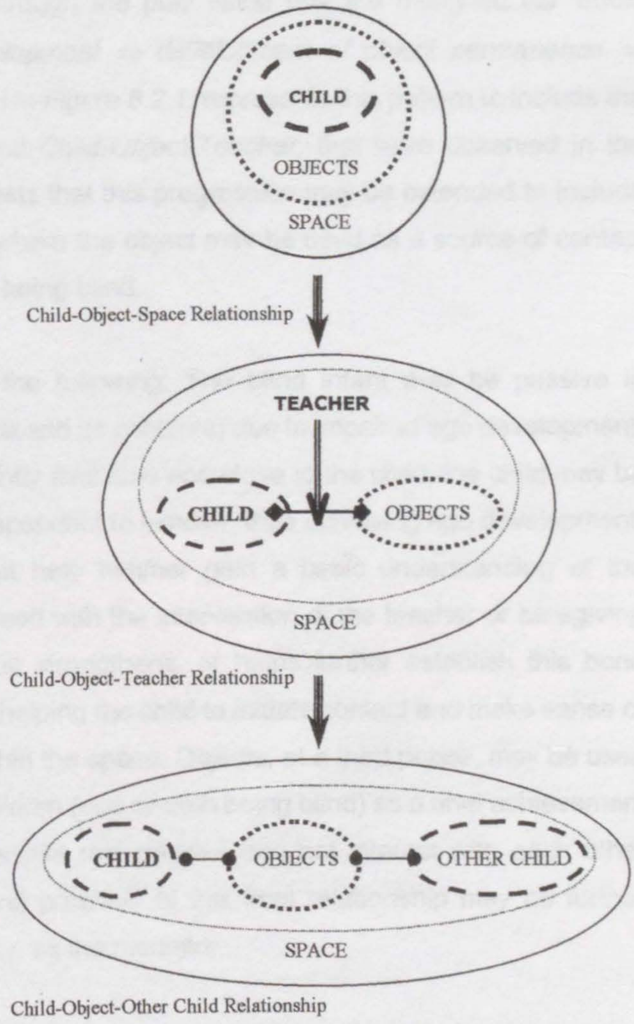


Figure 8.2.1. The model of developmental play behaviour verified as a result of the field study.

whole. The field testing methodology was initially envisaged as a comparative study between the designed toy and a toy of similar play value found in the market, to be able to assess the differences in play interest, with 10 play sessions with each toy, making 20 play sessions in total with each individual child. Due to the limited time available on the school's part, this idea had to be abandoned. Furthermore, due to the expertise required from the discipline of clinical psychology, not availed, the study was limited to a simple trial session among the user group. Within the scope of the thesis, which encompassed mainly the devising of a design process model and sought to reveal its implications on the design process, and reflection onto the output/product, the carrying out of a full-fledged field study was found of secondary importance, as the success of the model is not merely limited to the indications of the results of such a study.

The field study conducted within the context of the thesis implied that the children did show play interest in the realised component of the concept, particularly while in interaction with an adult. The play behaviour that the observed children displayed towards the learning toy developed through the design process model, conformed to the following pattern of cognitive development derived from the literature review in *Research Topic I* during the research stage. The pattern was offered as an objective to be achieved through the play value that the designed toy would provide, in the following order: *ego development* ⇒ *development of object permanence* ⇒ *development of spatial concepts*. The model in *Figure 8.2.1.* represents this pattern to include the two relationships of *Child-Object-Space* and *Child-Object-Teacher*, that were observed in the play sessions of the field test. It also suggests that this progression may be extended to include the *Child-Object-Other Child Relationship*, where the object may be used as a source of contact initiation between two children, one or both being blind.

The pattern in *Figure 8.2.1.*, represents the following: The blind infant may be passive in interactions with the surroundings (the space and its contents) due to impaired ego development. With objects used as play materials constantly available and close to the child, the child may be made aware of the existence of objects independent to him/her, thus achieving ego development. The relation of the child with objects that help him/her gain a basic understanding of the surrounding space may be further emphasised with the intervention of the teacher or caregiving adult in this relationship. The teacher/adult strengthens, or helps further establish this bond between the child and the world of objects, helping the child to initiate contact and make sense of the events that take place, with objects, within the space. Objects, at a third phase, may be used to initiate social interaction between two children (one or both being blind) as a final achievement of pre-school development, who may otherwise rest passive and not interact with each other though in the same space. The validity and potential of this final relationship may be further investigated, with the design product, the toy, as the mediator.

Another point may be that, the component of the play environment may be further studied with older pre-school children on the threshold of structured education, as to the learning material and activities it offers. Also, observations may be conducted to assess the imaginative and social play the toy may accommodate among more than one child. To assess the remaining components of the conceptual project, and the project as a whole, would be beneficial in order to understand the effects of the design model on the activity of design, and on this conceptual design project in particular. During this assessment of the total play system, the pattern of developmental play behaviour diagramatised in *Figure 8.2.1.*, may be further investigated and refined with studies on the blind pre-school child's interaction with those objects and toys. The design process model may also be used to develop other toy and play material and educational models in which these material would be used.

The implementation of the devised model which resulted with a product to which samples from the user group has shown play interest, may with further studies on the design decisions and field tests on the toy, be improved towards taking its place in an educational setting for the children. To follow up this work in the future, a comparative study as initially envisaged could be carried out, with at least 10 participants from the user group, to reveal the differences that the particular designed toy brings as novelty. It is recommended that such a study is carried out collaboratively, in team work to share the considerable amount of work and funding, to be able to realise the design and the envisaged environment with all the interactive components, and to obtain sound and discipline-related expert opinions, to prevent observer bias towards objective and correctly interpreted research results. An experience of such multidisciplinary collaboration would also ensure the distribution of these results as knowledge among disciplines which would like to benefit from their implications and would bring deeper insight on how design as a discipline, may contribute with the expertise it brings to collaborative research.

8.3. A FINAL WORD

Design has the role of searching for new expressions, new functions, new locations, in short new contents and contexts to man-made and man-used things. This role gains a different responsibility when there is a specific target at hand. Within the boundaries of a specific target, design research must have the aim of proposing design theories and practical design solutions that can answer problems encountered by specific user groups. In this sense, design has among its purposes, to accommodate an intense process for understanding, digesting and reinterpreting individual, social and cultural factors -considering the user group, and intellectual, technical, economic and ecologic factors, -considering the designer and manufacturer, with the designed product as a mediator between the two ends. One purpose of the design process then is, to found the grounds on which these two ends meet in the form of a product. On these grounds lie the social implications of design, as the design product will have a social impact.

This social responsibility lies on the shoulders of the designer who therefore has to structure the design process to assure the correctness of the decisions made throughout the process, questioning and going back to requestioning these decisions, to the aim that the output/product is true to its function, and has appeal and will be a positive asset as an offering to the society. This social consciousness and responsibility on the part of the designer has brought into the scene, the employment of design methods, and phase models as were discussed in *Chapters 2., 3.*, and *4.*. To repeat the hypothesis of the study, *due to the social, economic, and ecologic responsibilities that it carries, design needs to be conducted within a guided process to obtain a product that will best suit the system into which it will be integrated.* To accomplish the design task posed, *-an educational toy for visually impaired children-* a design model was devised based on a design process core as a structuring and knowledge-generating framework. This framework organised the activities, yet allowed flexibility back and forth, and did not deny efforts at creativity; required reseach and its processing; demanded knowledge at each stage, yet asked for their accumulative effectiveness.

In the hands of a different designer or design team, but with the same design task, the design process core, most probably, would have been built into a different model; or else, using the same design process model for the same design task, a different designer or design team would have developed a different design output, reflecting the differences in the approaches, subjective value judgements, and interpretations of the creative thinking involved. This interpretative quality of the design process core that is offered, thus allows for the reflection of the creative nature of the design act within a systematised design process model, in accordance with the approaches of the designers, and the responsibilities that the design task involves. The particular model devised, at times was a hard task-master, and at others smoothed the painful way of the designer. Its application was all in all, a rewarding experience in the sense that, even though the outcome was a product of a creative act, it was also based on rational grounds, through the structured framework that the model offered.

REFERENCES

CHAPTERS 1-6

ALEXANDER, C., 1970. *Notes on the Synthesis of Form.* Massachusetts: Harvard University Press.

ANDERS, R., 2000. Defining, mapping and designing the design process. *Design Management Journal.* ISSN 1045-7194. 11 (3), 29-37.

ARCHER, B.L., 1974. *Design Awareness and Planned Creativity in Industry.* Canada: Office of Design, and the Design Council of GB.

ARCHER, B., 1984a. Systematic Method for Designers. *In:* N. CROSS, ed. *Developments in Design Methodology.* Avon, UK: John Wiley & Sons.

ARCHER, B., 1984b. Whatever Became of Design Methodology? *In:* N. CROSS, ed. *Developments in Design Methodology.* Avon, UK: John Wiley & Sons.

ARCHER, B., 1999. Design, innovation, agility. *Design Studies.* ISSN 0142-694X. 20, 565-571.

BAXTER, M., 1996. *Product Design: Practical Methods for the Systematic Development of New Products.* London: Chapman & Hall.

BROADBENT, G.H., 1966. Creativity. *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

BROADBENT, G., 1984. The Development of Design Methods. *In:* N. CROSS, ed. *Developments in Design Methodology.* Avon, UK: John Wiley & Sons.

CHAPMAN, C., and M. PEACE, 1993. *Design and Realisation.* London: HarperCollins Publishers.

CROSS, N., 1997. Descriptive models of creative design: Application to an example. *Design Studies.* ISSN 0142-694X. 18, 427-455.

CROSS, N., 2000. Engineering Design Methods: Strategies for Product Design (3rd ed.). England: John Wiley & Sons Ltd.

CROSS, N., 2001. Designerly ways of knowing: Design discipline versus design science. *Design Issues.* ISSN 0747-9360. 17, 47-55.

EDER, W.E., 1966. Definitions and Methodologies. *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

EISENTRAUT, R., and J. GÜNTHER, 1997. Individual styles of problem solving and their relation to representations in the design process. *Design Studies.* ISSN 0142-694X. 18, 369-383.

FOQUE, R. and M. LAMMINEUR, 1995. Designing for patients: A strategy for introducing human scale in hospital design. *Design Studies.* ISSN 0142-694X. 16, 29-49.

GREGORY, S.A., 1966. Design and the Design Method. *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

JONES, J.C., 1966. Design Methods Reviewed. *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

JONES, J.C., 1980. *Design Methods: Seeds of Human Futures.* London: John Wiley & Sons.

JONES, J.C., 1984a. A Method of Systematic Design. *In:* N. CROSS, ed. *Developments in Design Methodology.* Avon, UK: John Wiley & Sons.

JONES, J.C., 1984b. How My Thoughts about Design Methods Have Changed during the Years. *In:* N. CROSS, ed. *Developments in Design Methodology.* Avon, UK: John Wiley & Sons.

JOSEPH, S., 1996. Design systems and paradigms. *Design Studies.* ISSN 0142-694X. 17, 227-239.

HANINGTON, B.M., 2000. Innovation and method in design research. *In:* S. PIZZOCARO, A. ARRUDA, D. De MORAES, eds. *Design Plus Research: Proceedings of the Politecnico di Milano Conference, May 18-20, 2000, Milan.*

HASDOGAN, G., 1996. The role of user models in product design for assessment of user needs. *Design Studies.* ISSN 0142-694X. 17, 19-33.

HEKKERT, P., 1997. Productive designing: A path to creative design solutions. *In: Proceedings of The Second EAD Conference, Stockholm* (http\\:www.svid.se/ead/ead-Hekkert.htm).

HESKETT, J., 1987. *Industrial Design.* Thames and Hudson Ltd.

HUBKA, V., and W.F. EDER, 1996. *Design Science: Introduction to the Needs, Scope and Organisaton of Engineering Knowledge.* Great Britain: Springer-Verlag London Ltd.

LAMBERT, S., 1993. *Form Follows Function? Design in the 20th Century.* London: Victoria & Albert Museum.

LAWSON, B., 2000. *How Designers Think: The Design Process Demystified (3rd ed.).* Great Britain: Biddles Ltd.

LINDBECK, J.R., 1995. *Product Design and Manufacture.* USA: Prentice-Hall, Inc.

MANZINI, E., 2000. Design research: Reasons and possibilities/The production of a design knowledge: Taking time in the age of real-time. *In:* S. PIZZOCARO, A. ARRUDA, D. De

MATCHETT, E., and A.H. BRIGGS, 1966. Practical Design Based on Method (Fundamental Design Method). *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

MARGOLIN, V., ed, 1989. *Design Discourse: History-Theory-Criticism.* USA: The University of Chicago Press.

MARGOLIN, V., 1997. Getting to know the user. *Design Studies.* ISSN 0142-694X. **18**, 227-236.

MAYALL, W.H., 1966. Design and Human Satisfaction. *In:* GREGORY, S.A., ed. *The Design Method. London: Butterworths.*

MAYALL, W.H., 1979. *Principles in Design.* UK: A. Wheaton & Co Ltd.

MCCRORY, S.A., 1966. The Design Method in Practice. *In:* GREGORY, S.A., ed. *The Design Method.* London: Butterworths.

MCDONAGH-PHILIP, D., and H. DENTON, 1999. Using focus groups to support the designer in the evaluation of existing products: A case study. *The Design Journal.* ISSN 1460-6925. 2(2), 20-31.

MORRISON, J., and J. TWYFORD, 1996. *Design: Capability and Awareness.* Singapore: Longman Singapore Publishers Pte Ltd.

NORMAN, D.A., 2000. *The Design of Everyday Things.* USA: MIT Press.

OLIVER, M., 1996. *Understanding Disability: From Theory to Practice.* London: MacMillan Press, Ltd.

OWEN, C.L., 1986. Structured Planning: A Concept Development Process. *In:* Proceedings of the International Symposium and Workshop on Industrial Design, Tainan/Taiwan, National Cheng Kung University, June 2-7, 1986 [8].

OWEN, C.L., 1998. Design research: Building the knowledge base. *Design Studies.* ISSN 0142-694X. 19, 9-20.

OWEN, C., 2001. Structured Planning in Design: Information-Age Tools for Product Development. *Design Issues.* ISSN 0747-9360. 17, 27-43.

PAHL , G. and W. BEITZ, 1996. WALLACE, K., ed. *Engineering Design: A Systematic Approach.* Translated from German by K. WALLACE, L. BLESSING, and F. BAUERT. Great Britain: Springer-Verlag London Ltd.

PAPANEK, V., 1991. *Design for the Real World: Human Ecology and Social Change.* London: Butler & Tanner, Ltd.

PAPANEK, V., 1995. *The Green Imperative: Ecology and Ethics in Design and Architecture.* London: Thames and Hudson Ltd.

POGRUND, R.L., D.L. FAZZI, and J.S. LAMPERT, eds, 1992. *Early Focus: Working with Young Blind and Visually Impaired Children and Their Families.* New York: American Foundation for the Blind.

PUGH, S., 1996. CLAUSING, D., and R. ANDRADE, eds. *Creating ınnovative Products Using Total Design.* Canada: Addison-Wesley Publishing Company Inc.

RAMS, D., 1998. The responsibility of design in the future. *In:* T. BALCIOGLU, ed. *The Role of Product Design in Post-Industrial Society.* Ankara: METU Faculty of Architecture Press.

RAWSON, P., 1987. *Creative Design: A New Look at Design Principles.* London: MacDonald & Co. Ltd.

RESTREPO, J., H. CHRISTIAANS, and A. RODRIGUEZ, 2000. The finality argument on design methods. *In:* S. PIZZOCARO, A. ARRUDA, D. De MORAES, eds. *Design Plus Research: Proceedings of the Politecnico di Milano Conference, May 18-20, 2000, Milan.*

ROOZENBURG, N.F.M. and J. EEKELS, 1995. *Product Design: Fundamentals and Methods.* England: John Wiley & Sons Ltd.

ROYAL NATIONAL INSTITUTE FOR THE BLIND, 1992. *Blind and Partially Sighted Children in Britain: The RNIB Survey Volume 2.* London: HMSO.

RUST, C., J. RODDIS, and P. CAHMBERLAIN, 2000. A practice-centred approach to research in industrial design. *In:* S. PIZZOCARO, A. ARRUDA, D. De MORAES, eds. *Design Plus Research: Proceedings of the Politecnico di Milano Conference, May 18-20, 2000, Milan.*

SCOTT, E.P., J.E. JAN, and R.D. FREEMAN, 1977. *Can't Your Child See?* Baltimore: University Park Press.

SHADRIN, R.L., 1992. *Design and Drawing: An Applied Approach.* Massachusetts: Davis Publications, Inc.

SMITH, R.P., and J.A. MORROW, 1999. Product development process modeling. *Design Studies.* ISSN 0142-694X. 20, 237-261.

SNOEK, H., and P. HEKKERT, 1998. Directing designers towards innovative solutions. *In:* B.

TORRENS, G., 2000. Understanding the product user: The implementation of a user-centred design approach by student industrial designers when designing for elderly and disabled people. *The Design Journal.* ISSN 1460-6925. 3(1), 15-29.

TOVEY, M., 1997. Styling and design: Intuition and analysis in industrial design. *Design Studies.* ISSN 0142-694X. 18, 5-31.

von der WETH, R., 1999. Design instinct? –the development of individual strategies. *Design Studies.* ISSN 0142-694X. 20, 453-463.

WHITELEY, N., 1998. *Design For Society.* London: Reaktion Books Ltd.

WRIGHT, I., 1998. *Design Methods in Engineering and Product Design.* England: McGraw-Hill Publishing Company.

CHAPTER 7

BRAMBRING, M., and H. TRÖSTER, 1992. On the stability of stereotyped behaviours in blind infants and preschoolers. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 86(2), 105-110.

THE BRITISH TOY AND HOBBY ASSOCIATION, 1997. *The Toy Industry in the UK.* London: Biddles, Ltd.

THE BRITISH TOY AND HOBBY ASSOCIATION, 2000. *The Official BTHA Handbook and Guide to the 47th British International Toy & Hobby Fair.*

BROWN, K.D., 1996. *The British Toy Business.* London: Hambledon Press.

BROWN, K.D., 1998. Design in the British toy industry since 1945. *Journal of Design History.*

ISSN 0952-4649. 11(4), 323-333.

BURTON, A., 1996. *Children's Pleasures.* London: V & A Publications.

BUULTJENS, M., and R. FERGUSON, 1994. Let's play together! *The British Journal of Visual Impairment.* ISSN 0264-6196. 12(3), 87-89.

CEN Report, 2000. *Child Safety: Risk Assessment and Design Solutions.* Stockholm: SIS Forlag AB.

CHILD ACCIDENT PREVENTION TRUST (CAPT), 1998. *Toy Safety Factsheet.*

CONSUMER PRODUCT SAFETY COMISSION (CPSC) Website (www.cpsc.gov).

DIXON, B., 1992. *Playing Them False: A Study of Children's Toys, Games and Puzzles.* London: Trentham Books.

DOTE-KWAN, J., and M. HUGHES, 1994. The home environments of young blind children. *Journal of Visual impairment and Blindness.* ISSN 0145-482X. 88(1), 31-42.

DREW, C.J., and M.L. HARDMAN, 1988. *Designing and Conducting Behavioural Research.* Oxford: Pergamon Press.

DUNNETT, J., 1997. Nielsen's little Room: Its use with a young blind and physically disabled girl. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 91(2), 145-150.

FERGUSON, R., and M. BUULTJENS, 1995. The play behaviour of young blind children and its relationship to developmental stages. *The British Journal of Visual Impairment.* ISSN 0264-6196. 13(3), 100-107.

FRAIBERG, S., 1977. *Insights from the Blind.* London: Souvenir Press.

FRASER, A., 1972. *A History of Toys.* London: The Hamlyn Publishing Group Ltd.

GIELEN, M.A., P. HEKKERT, and C.M. VAN OOY, 1998. Problem restructuring as a key to a new solution space: A sample project in the field of toy design for disabled children. *The Design Journal.* ISSN 1460-6925. 1(1), 12-23.

HAINSTOCK, E., 1978a. *The Essential Montessori.* New York: Mentor, The New American Library Inc.

HAINSTOCK, E., 1978b. *Teaching Montessori in the Home. The School Years: Supplementing Your Child's Education as the Basic Math and Language Skills.* New York: Plume, The New American Library Inc.

INTERTEK TESTING LABORATORIES, 1997. *Toy Safety: The Law in Brief Factsheet.*

JACKSON, L., 1999. Dinosaurs walk all over their cyber rivals. *The Sunday Telegraph Newspaper*, Sunday, October 17, p. 11.

LANGLEY, B., 1985. Selecting, adapting and applying toys as learning tools for handicapped children. *Topics in Early Childhood Special Education.* ISSN 0271-1214. 5(3), 101-118.

LEWIS, V., 1992. *Development and Handicap.* Oxford: Blackwell Publishers.

LEWIS, V., 1992. *Development and Handicap.* Oxford: Blackwell Publishers.

MCHUGH, E., and J. PYFER, 1999. The development of rocking among children who are blind. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 93(2), 82-95.

MILLAR, S., 1994. *Understanding and Representing Space: Theory and Evidence from Studies with Blind and Sighted Children.* New York: Clarendon Press.

MONTESSORI, M., 1988. *The Discovery of the Child.* Oxford: Clio Press.

MURPHY, G., M. CALLIAS, and J. CARR, 1986. Increasing simple toy play in profound mentally handicapped children. II. Designing special toys. *Journal of Autism and Development Disorders.* ISSN 0162-3257. 16(1), 45-58.

NIELSEN, L., 1979. *The Comprehending Hand.* Translated from Danish by A. ROBINSON. Copenhagen: Socialstyrelsen – National Board of Social Welfare.

NIELSEN, L., 1990a. *Are You Blind?* Copenhagen: Jelling Bogtrykkeri as.

NIELSEN, L., 1990b. *Spatial Relations in Congenitally Blind Infants.* Denmark: National Institute for Blind and Partially Sighted Children and Youth.

NIELSEN, L., 1991. Spatial relations in congenitally blind infants: A study. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 85(1), 11-16.

NIELSEN, L., 1992. *Space and Self: Active Learning by Means of the Little Room.* Copenhagen: Ry Bogtrykkeri as.

NORRIS, M., P.J. SPAULDING, and F.H. BRODIE, 1957. *Blindness in Children.* Chicago: The University of Chicago Press.

O'DONNELL, L.M., and R.L. LIVINGSTON, 1991. Active exploration of the environment by young children with low vision: A review of the literature. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 85(7), 287-291.

PARSONS, S., 1986a. Function of play in low vision children (Part 1): A review of the research and literature. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 80(3), 627-630.

PARSONS, S., 1986b. Function of play in low vision children (Part 2): Emerging patterns of behaviour. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 80(6), 777-784.

PIAGET, J., 1977. *Origin of Intelligence in the Child.* Translated from French by M. COOK. England: Penguin Education.

PIAGET, J., and B. INHELDER, 1997. *The Child's Conception of Space.* London: Routledge.

PICK, H.L., and L.P. ACREDOLO, 1983. *Spatial Orientation: Theory, Research and Application.* New York: Plenum Press.

POGRUND, R.L., D.L. FAZZI, and J.S. LAMPERT, eds, 1992. *Early Focus: Working with Young Blind and Visually Impaired Children and Their Families.* New York: American Foundation for the Blind.

POTEGAL, M., ed, *Spatial Abilities: Development and Physiological Foundations.* New York: Academic Press. 1980.

QUILLIAM, S., 1994. *Child Watching: A Parent's guide to Children's Body Language.* London: Ward Lock.

RECCHIA, S.L., 1997. Play and concept development in infants and young children with severe visual impairments: A constructivist view. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 91(4), 401-406.

RETTIG, M., 1994. The play of young children with visual impairments: Characteristics and interventions. *Journal of Visual impairment and Blindness.* ISSN 0145-482X. 88(5), 410-420.

REYNELL, J., 1978. Developmental patterns of visually handicapped children. *Child: Health and Development.* 4 (5): 291-303.

RIDDICK, B., 1982. *Toys and Play for the Handicapped Child.* Great Britain: Billing and Sons Ltd.

ROSS, S., and M.J. TOBIN, 1997. Object permanence, reaching, and locomotion in infants who are blind. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 91(1), 25-30.

SCHNEEKLOTH, L.H., 1989. Play environments for visually impaired children. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 83(4), 196-201.

SCHOGGER, D., 1999. Old before their time. *Design Week.* 30 March, p. 8.

SHAPIRO, M.S., 1983. *Child's Garden: The Kindergarten Movement from Froebel to Bewey.* USA: The Pennsylvania State University.

SHARMAN, C., W. CROSS, and D. VENNIS, 2000. *Observing Children: A Practical Guide.* London: Cassell.

SKELLENGER, A.C., and E.W. HILL, 1994. Effects of a shared teacher-child play intervention on the play skills of three young children who are blind. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 88(5), 433-445.

SKELLENGER, A.C., L.P. ROSENBLUM, and B.K. JAGER, 1997. Behaviours of pre-schoolers with visual impairments in indoor play settings. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 91(6), 519-530.

SPENCER, C., M. BLADES, and K. MORSLEY, 1989. *The Child in the Physical Environment.* Bath: John Wiley & Sons, Ltd.

SWARTZ, E.M., 1971. *Toys that Don't Care.* Boston: Gambit Inc.

TAIT, P., 1972a. The effect of circumstantial rejection on infant behaviour. *The New Outlook for the Blind.* 66(5), 139-151.

TAIT, P., 1972b. Behaviour of young blind children in a controlled play session. *Perceptual and Motor Skills.* ISSN 0031-5125. 34, 963-969.

TERRY, G., and F.G. SHAFFNER, 1972. Visually handicapped children who function on a retarded level: The Frances Blend School, Los Angeles. *The New Outlook for the Blind.* 66(5), 135-138.

TOY MANUFACTURERS OF AMERICA (TMA) Website (www.toy-tma.com).

TRÖSTER, H., and M. BRAMBRING, 1994. The play behaviour and play materials of blind and sighted infants and pre-schoolers. *Journal of Visual Impairment and Blindness.* ISSN 0145-482X. 88(5), 421-432.

UKTN, November/December 1999. Barbie and Steffi under fire from supermarkets. *UK Toy News.* p. 3.

UKTN, February 2000. Kids don't have time for toys. *UK Toy News.* p. 28.

WARREN, D.H., 1984. *Blindness and Early Childhood Development.* New York: American Foundation for the Blind.

WARREN, D.H., 1994. *Blindness and Children: An Individual Differences Approach.* USA: Cambridge University Press.

WILLS, D.M., 1968. Problems of play and mastery in the blind child. *British Journal of Medical Psychology.* ISSN 0007-1129. 41, 213.

APPENDIX A

TOY CATEGORIES

The following categorisation of toys is made according to age, activity type and play value, based on a categorisation by the BTHA (1997, 2000):

Infant/pre-school toys

Cot and playpen accessories, rattles, teethers.

Discovery and activity toys, musical toys, learning toys.

Dolls

Baby dolls, fabric, plastic or porcelain dolls, and accessories.

Girls' dolls such as fashion and hair dolls.

Boys' dolls such as action figures, robot dolls and transformer figures.

Plush

Teddy bears, animals.

Character Licence toys

Soft toys, figures, cards and games, accessories of TV, film and video game characters.

Pretend play

Pretend play props such as kitchens, cleaning, housework toys, tool sets, doctor's sets.

Pretend costumes and accessories such as princess outfits and Superman outfits.

Scenery toys such as village, street, farm and space scenes.

Ride-on toys

Rocking horses, plastic cars, pedalling animals.

Tricycles, bicycles, scooters.

Vehicles

Toy cars, boats, planes, railway sets for all ages.

Radio control vehicles.

Construction sets

Wooden blocks, plastic locks, foam locks, gears, abstract pieces.

Motorised or radio-controlled sets.

Indoor and outdoor (physical) activity toys

Sand and water play pools, sand and water toys.

Swings, slides, climbing equipment, tents, houses.

Games for bodily activity such as Twister, etc.

Sports props, kites, hula-hoops etc.

Games and puzzles

Card and board games, electronic games, jigsaw puzzles, puzzle chains, etc.

Arts and crafts

Paints, crayons, pens, beads, clay, etc, and related material and props.

Animal crayons, puzzle crayons, scented pens, Spirograph.

Books

Colouring books, picture books, learning to read books.

Story books, first encyclopaedias, fiction books, comics, pop-up books.

Electronic learning aids

Children's computers, interactive toys.

Children's electronics and accessories such as data banks and electronic pets.

Video games

Smart Toys

Advanced interactive electronic toys that are programmed to acquire skills depending on the treatment they receive from the owners, such as the Sony AIBO.

Other

Yo-yos, Rubik's cube, Slinky, bubble blowers, etc.

APPENDIX B

LIST OF BEHAVIOURS THAT MAY OCCUR WITH ZOG

A. Contacting and manipulating the objects of Zog

Handling one or more objects and feeling the form and textures

Picking objects off their sockets

Observing the lines, dots and textures some objects have

Observing the flickering lights that some objects have and making the lights go on and off

Observing the soft feel of the sponge objects, squeezing them for sound and observing their smell

Observing the sockets and the legs

Feeling the textured shapes and tactile patterns on the leg surfaces

Feeling the shapes of the sockets

Discovering and replacing the objects into the sockets they belong

Searching for the socket that belongs to an object the child is handling

Searching for a missing object

Listening to the sound effects when some of the objects are replaced, and repeating the activity to hear more

B. Contacting and manipulating Zog as a whole

Observing the face, horns, and the tail

Observing the body, climbing on and sitting on the body, getting off

Active spatial involvement

Actively searching for objects

Actively exploring the legs

Spatial activities around Zog

C. Avoiding toy contact and manipulation with Zog and/or its features

Refusing to touch objects by using verbal or physical expressions (crying, pushing away, moving away from, saying so)

Throwing objects to cease contact

Moving off to play somewhere else

Sitting not playing with anything

D. Social interaction with the teacher about the objects and activities (learning /socialisation)

Counting the dots, and following the lines on the objects

Counting the objects

Counting the tactile clues on the legs around some sockets

Placing objects on sockets together

Asking for help in finding matching objects

Sharing/exchanging objects

Making musical sounds together

Listening to the letters and numbers

Counting the four objects representing the number 4 on Zog

Matching textures of objects and frames around sockets together

Discussing the names of the scents that some objects leave on fingers

Following tactile cues from the objects on the front left leg leading to the corresponding song

Discussing Zog's face, tail

Discussing Zog's body and sitting on it together

Inviting to play

Verbal and physical expressions towards teacher related to the toy

Co-operating in an activity

Waiting for turns

E. Imaginative play with Zog

Talking to Zog, talking about Zog as a personified character

Feeding Zog, nursing it

Patting Zog, grooming it

Riding Zog somewhere, taking it for a ride

Using Zog, its objects and its features to represent other things

Pretending to do things by using the objects or features

F. Repetitive/inappropriate play behaviour with Zog, its features or its objects

Playing the songs over and over again

Pressing the letters and numbers over and over again for sound

Repeatedly squeezing / smelling the sponge objects for stimuli

Banging objects on a surface

Watching flickering lights repeatedly

Pulling the vibrating tail repeatedly

Being fixated to a certain object

Mouthing objects

Throwing objects as play

G. Self-stimulating behaviour

Hand flapping

Eye poking

Rocking

Hitting head *etc.*

APPENDIX C

THE OBSERVATION SESSIONS

***1st child, 1st session:** C. (2 y, 9 m) has visual impairment from albinism.*

***Date:** 13.11.2000 **Time:** 10:15 - 10:20*

C. comes in with volunteer staff member. He is introduced to the toy by the staff member as 'Look C., A big dog to ride on!' He is very boisterous and when he is shown Zog his first reaction is to climb on it and force it to wobble up and down with his body strength. He goes on and off a few times, as he is small in size he has difficulty in climbing. He discovers the tail, and pulls it a few times. He is very talkative about the toy, but his interest is short. He is then attracted by other play props and objects stacked in the room, and goes off asking about them. The staff member tries to encourage him back, he then explores the face. He is not interested in the objects on the legs. He soon asks where the others are and so the teacher takes him back to the classroom.

***1st child, 2nd session:** C.*

***Date:** 20.11.2000 **Time:** 10:10 – 10:25*

C. comes in with Maggie this time. He recognises Zog straight away, and walks towards it, climbs from the right and sits on it. He wobbles. Maggie asks 'What do you remember from this toy?' I say 'He liked the tail,' C. gets off and goes to the back for the tail. He pulls it a few times, smiles. Maggie says 'Oh, you pulled off the tail, oh, it's coming back by itself... oh you pulled it off again, there, it's returning ... Listen to it, what sound is it making?' C. brings his ear close to the ball, listens to the sound. Maggie says 'It's like a cat purring isn't it?' They then play vets. Maggie says

- You pulled off the tail, now let's take it to the vet so he'll fix it.
- Yes.
- Are you the vet?
- I am.
- Let's go, there, it's back, you've mended the tail.
- Yes I did.

The three-point star falls off, and flashes. Maggie picks it up, shows it to C. C. holds it, when he shakes it, it flashes. 'It's flashing!' He shakes it over and over again a few times. Maggie asks 'Where does this come from?' C. is on Zog shaking the star 'It's flashing.' 'Where does this fit C.?' C. gets off, goes to the back next to Maggie, she asks again 'Where does it go?' C. goes to a cardboard box full of big Lego pieces. He puts his arm in it holding the star 'Here.' 'No it doesn't go there.' C. returns to Maggie. Maggie pulls the four-point star from the leg to try it. 'Does this flash as well?' asks Maggie. This star does not flash light. C. says 'No it doesn't.' Maggie asks 'Can you find where the flashing star fits?' C. kneels down, bends over to the side, finds the star frames. 'If Maggie puts one in, will C. try to put the other?' 'Yes.' Maggie places her star on the leg. C. tries the other, from a correct angle, but upside down. Maggie says 'Well tried C.' and helps him correct it. C.'s head contacts the letter B. He is surprised at the sound B makes. They press A, B, and C and listen to the sounds. Maggie says 'C for C.' after the letter C and C. says 'Yes!' Then C. leaves to play with the tail again. Then he climbs on Zog, making 'eee, eee' noises. Maggie goes to the front to hold the horns for him. C. is wobbling up and down and is pressing down from the spheres. 'It's a fire engine' he says. 'Is it a fire engine?' 'Yes.' C. gets off, goes to a corner with his hands and arms in front. 'I'm putting the fire out.' He gets on Zog again, 'eee, eee.' Maggie asks 'Are these the lights of your fire engine in the front?' showing the hollow rectangle and circle. C. raises himself on his seat, bends over the head to see. He touches the eyes and says 'These are my lights.' He gets off, *puts out* another fire in the opposite corner, returns and climbs on again. Maggie asks 'What are these then?' about the rectangle and circle. C. gets off to see, comes around to Maggie. Maggie drops off the red circle for him. He is on his knees observing closely 'A circle.' He looks at where it came off from. He touches the holographic center bit. He takes the rectangle off and touches its holographic center. He puts the circle back, he puts the rectangle back. Maggie asks their names, he tells their names as he places them. Maggie shows him the triangle at the side, but C. has left, he climbs on Zog again. 'It is not a fire engine, it is a car.' 'Okay, it's your car. Where are you driving?' '...' 'Are you driving to the shops?' 'Yes ... vrooom vrooom... I need petrol for my car.' Maggie pats the left side of the legs on the sponge flowers and asks 'Are these your petrol caps?' C. gets off, kneels, observes and touches 'Yes they are... Ah, they're soft... One's got a hole.' Maggie asks 'Is the other one noisy? Does it make a sound?' C. squeezes with his right hand, between the thumb and index fingers. One squeeze makes a noise; he squeezes from the side, so the other attempts do not make noise. He keeps the flower with the hole which has five petals, in his hand. He fills in petrol and Maggie asks him to place the *cap* back on. C. pushes the five-petal flower into the socket for 6 petals, it drops off after a while. Maggie shows him as she puts it back on. Then he climbs on again, *drives* to the seaside. Maggie 'Ah, came to the beach, what lovely sand (she sweeps the carpet with her hand), and the right colour too.' C. gets off and sweeps with his hand as well 'Yes.' The floor in front of Zog is the sea. He imitates waves in the sea, with sound effects and moving his arms. Maggie asks 'And are these seashells?' she means the sponge flowers. C. puts them together on the floor and says 'Yes.' 'Are they noisy sea shells?' C. squeezes one making a squeak sound, 'Yes, noisy! ... This one doesn't have a hole, I can put my finger in this one's hole.' 'Yes you can.' Then by coincidence, someone turns the water tap on in the kitchen, and sound comes from the water pipes. Maggie says 'Oh that's the sea sound.' C. bends down to listen, 'Yes... Oh waters coming quick, move.' He pushes Maggie aside, and sits on the floor. Maggie picks his left foot, 'Oh you've got wet feet.' C. gets up and climbs on Zog again. Maggie makes 'Swish swish swish, you are on your boat' and C. sways from left to right on the boat. Then Maggie says 'You've played a lot, is it time to stop?' C. agrees. He gets off, and Maggie says 'Say bye-bye to doggie', 'Bye bye doggie.' I say 'Bye bye C.' he says 'Bye bye,' Maggie says 'Say bye-bye Naz,' C. says 'Bye-bye Maz.' They leave the room hand in hand.

2nd child, 1st session: *J. (3 y, 1 m) has residual vision.*

Date: *15.11.2000* ***Time:*** *10:15 – 10:22*

J. comes in the room at 10:15 after his mobility training, and before snack time, on Maggie's lap. Maggie says 'J. you have been a very good boy today so I will take you to play with a very special toy', J. makes a few steps with the help of his teacher. 'Now let's open the door... what do we have here?' J. is very attentive, as he is pleased with himself, he is positively responsive to ongoing events. Maggie sits with J. on the left front side of Zog. She comments on and touches the basic shapes surface of the front leg. J. touches as well. She touches the soft flowers in the front face, J. touches, but removes his hands. Maggie sits J. with his feet apart in front of the toy. J. shows interest, his hands are exploring the front faces of the legs. He discovers the rectangle, pulls at it. Maggie takes it out for him. He holds it with one hand, explores with both, then he uses both hands to place it back in its socket. This requires help from Maggie. He pulls it out again, with one hand he tries to pull out the shiny center bit, he then explores the socket, and around the socket. He puts the rectangle back with Maggie's help. He explores the faces of the legs, but avoids the sponges. He comes across the circle but does not pull them out, it is too low on the leg for him to pull out comfortably. He explores further up, comes across the bell, and hits the bell two-three times. Maggie comments on this, and sings a song about a bell, he joins in by hitting the bell. When playing with the rectangle again, he bumps his head as he is seated close to Zog but does not hurt himself, he seems puzzled. Then he holds his forehead against Zog's chin to feel it.

Maggie makes J. stand up to explore the face. They both run their hands over and around it, Maggie says this is smooth. They come across the eyes. J. explores with both hands the eye texture, eyeballs and frame, then with Maggie's prompt, he scratches the eye surface (which is textured in contrast to the smooth head surface) for some time. Maggie shows him the horns and balls. He holds the right ball and the left ball at the same time. Maggie then sings 'pat the dog' and J. joins in the patting part. Finally Maggie sits J. on the seat. J. has a slight problem with his legs, he cannot sit long with his legs apart. He puts his feet on the front legs, Maggie helps him hold on to the horns and balls. In the meantime Maggie sings 'pat the dog' again and they both pat Zog on the head. J. is excited and talks babble language for some time, riding on the toy. Then it is snack time, and Maggie takes J. to have his yogurt with his friends.

2nd Child, 2nd Session: *J.*

Date: *7.3.2001* ***Time:*** *10:35 – 10:37 / 10:55 – 10:58*

J. is not feeling very well this session, he has constipation and is very uncomfortable. He comes into the session after his free-play in the gym, during which he has been crying and was difficult to calm. Maggie has J. in her lap, and as she brings him in, she talks to him: 'Let's see if we can find you a toy that can cheer you up.' J. is attentive, but as Maggie puts him down on the left side of Zog, he starts crying again. Maggie picks him up talking soothingly and asks if he remembers

Zog. She makes his hands feel Zog's head and horns. J. starts crying again so Maggie picks him up and takes him to the toilet.

About 20 minutes later they come back. J. sits with me on the floor in front of Zog. I ask him 'J., do you remember Zog? Do you remember you explored its face.' J. has his hands on the face exploring the eyes and the nose. His hands stay on the nose as it is soft and he can squeeze it. I offer him a sponge flower, when he comes into contact with it, he refuses. But then it is time for his music lesson and Mrs. Tandy takes J. to his class.

***3rd child, 1st session:** R. (3 y, 3 m) is severely visually impaired, has slight residual vision in his right eye.*

***Date:** 16.11.2000* ***Time:** 10:15 – 10:25*

Before coming in the room R. attends his cooking class with two other children and a teacher each, where they bake flapjacks. They are first asked to taste or feel the ingredients, then stir the bowl each time an ingredient is added. R.'s first reaction to requests of touching, tasting and stirring is 'no' to begin with, but it seems he actually enjoys the activity. He touches and stirs each time he is asked. Before Maggie brings him in, she tells me he is reluctant in touching things.

As they come in R. is quick to approach Zog, and asks 'What is this?'. Maggie asks him in return 'What is it?'. R. first says it is a duck, then he says it is a car. And he repeatedly says it is a car for a few times. Maggie explains cars have wheels, but this toy does not, and she tries to encourage him into play by asking him to see what there is instead of wheels. But rather than the legs, R. is interested in the body and the head. He leans on the body and observes the seat surface. Maggie brings him in front of the face, R. observes the face features. Maggie says 'It is not a car, it has a face'. R. is not interested. He turns around to look for other toys. Maggie then plays music for him on Zog's front leg, R. comes and kneels to hear where it comes from. He puts his right ear on the back leg, then he puts his right ear on the front leg where the music plays. Maggie then helps him to use his finger to show how to start music and they press the shape together. R. listens, when it is over he says 'nice'. He does not play any further and wanders off to the Lego box, in which he searches for cars and trucks (Maggie leaves us). He finds lots of 'cars', 'trucks' and 'tractors' and we play. Then it is lunchtime and a teacher comes to pick him up. As he leaves he is told to say 'bye bye' to me, and by himself he says 'bye bye woof woof' as he passes Zog.

***3rd child, 2nd session:** R.*

***Date:** 23.11.2000* ***Time:** 10:10 – 10:20*

R. is brought in by Maggie after his baking class where they made Christmas cookies. He is holding Maggie's hand, and with his right hand he is poking his eye with the forefinger, he has his thumb pressed in the corner of his mouth. Maggie kneels by the left side of Zog and asks 'What do we have here?' R. walks on to a box at the end of the room saying 'The car, the car...' Maggie says, 'We'll find the car later on, now come and play with this'. R. continues 'The car, the car...'

Maggie sits and holds R.'s hand and brings him around. I suggest the tail. Maggie shows the tail 'Here, its got a vibrating tail. What's happened? (after pulling it) It's coming back, feel.' R. interested, bends head to see with the inner corner of his left eye. He approaches his head, and kneels. Maggie asks 'Do you want to pull the tail?' R. brings his right hand but pulls to the left side, not straight towards himself. Maggie suggests 'Use both hands'. She helps him bring his left hand on the ball, he has to sit on his bottom now, and they pull together. R. listens to the sound as the ball vibrates back. Maggie 'I like the sound it makes, it is like purring'. R. has now learnt how to pull. He pulls with both hands then listens with his left ear by approaching his head. He does this a few times. Then his knee pushes the letter B. B makes the B sound. R. explores B in its socket, pushes and gets a reaction from it. R. lies on his tummy and pushes B with his right hand, pushes A, pushes C, pushes B, B, C and A.

His chest comes across the three-pointed star. He picks it, and brings it near the eye. Maggie says 'Shake it R., it flashes'. R. observes the flashing light. Maggie puts the star back because it has protruding bits and R. tends to bring objects very close to his eye, also to poke his eye with them. R. says 'Square'. R. is up. He pulls the tail two times. Maggie is by the left side of Zog and she says 'Come round here and lets see what shapes we can find.' 'No.' 'Come here, feel this.' R. comes to Maggie. Maggie takes R.'s both hands to the square. R. is silent. 'There's a square. Feel the funny soft bit (the sponge square pad on the surface). Let's pull it out (velcro attachment). ... That's a funny noise.' She puts the square between R.'s two hands. 'There's a square, feel the soft bit... Shall we find another shape?' '...' 'No? Put it back.' R. leans forward to put the object back. He finds the correct place, tries to put it in an angle. He pushes with both hands. Maggie helps him put it straight in. Then she moves R.'s right hand to the side of the leg, 'What else can we find here?' She presses on the top button of the music bar, and music plays. R. is on the floor sitting on his bottom. He does not hear, there are noises from the corridor. The noises run down, he hears the music, approaches his head. When it is finished, Maggie says 'Shall we play more? Do you want to find the button?' She leads his finger on the second button, another song plays and R. listens. Then the session is over and Maggie takes R. to lunch.

4^th^ child, 1^st^ session: *M. (2y, 11 m) has no vision since birth.*

Date: *22.11.2000* ***Time:*** *10:15 – 10:19*

J. is not in today for a second session, so Maggie suggests to bring in a new child, M. Another teacher, Jane comes in with her. M. is having mobility lessons to learn to walk alone. She has a favourite toy, which she always carries around with her in her left hand. She is taught to keep her head up as she walks. She is responsive to her teachers.

M. walks into the room and finds Zog at the center. She uses it as a base. She stands up facing it, then she turns her back on it, leaning the left side. Jane kneels with her, takes her right hand, tries to encourage her to explore the numbers as they have a bit of light and sound. M. refuses touching by standing still and pulling her hand away. Jane tries to show the vibrating tail, pulls the tail and it vibrates. But again M. does not come around, although she listens to the vibrating sound. She starts babbling and rocking to and fro, refusing to move away from her position. When not rocking to and fro, she leans on Zog and stamps her feet. She is babbling and swaying to and fro. We decide we do not go on any further. Jane takes M.'s hand and tells her they are going to the music class. M. takes her hand and leaves, babbling.

4th Child, 2nd Session: *M. (3 y, 3 m)*

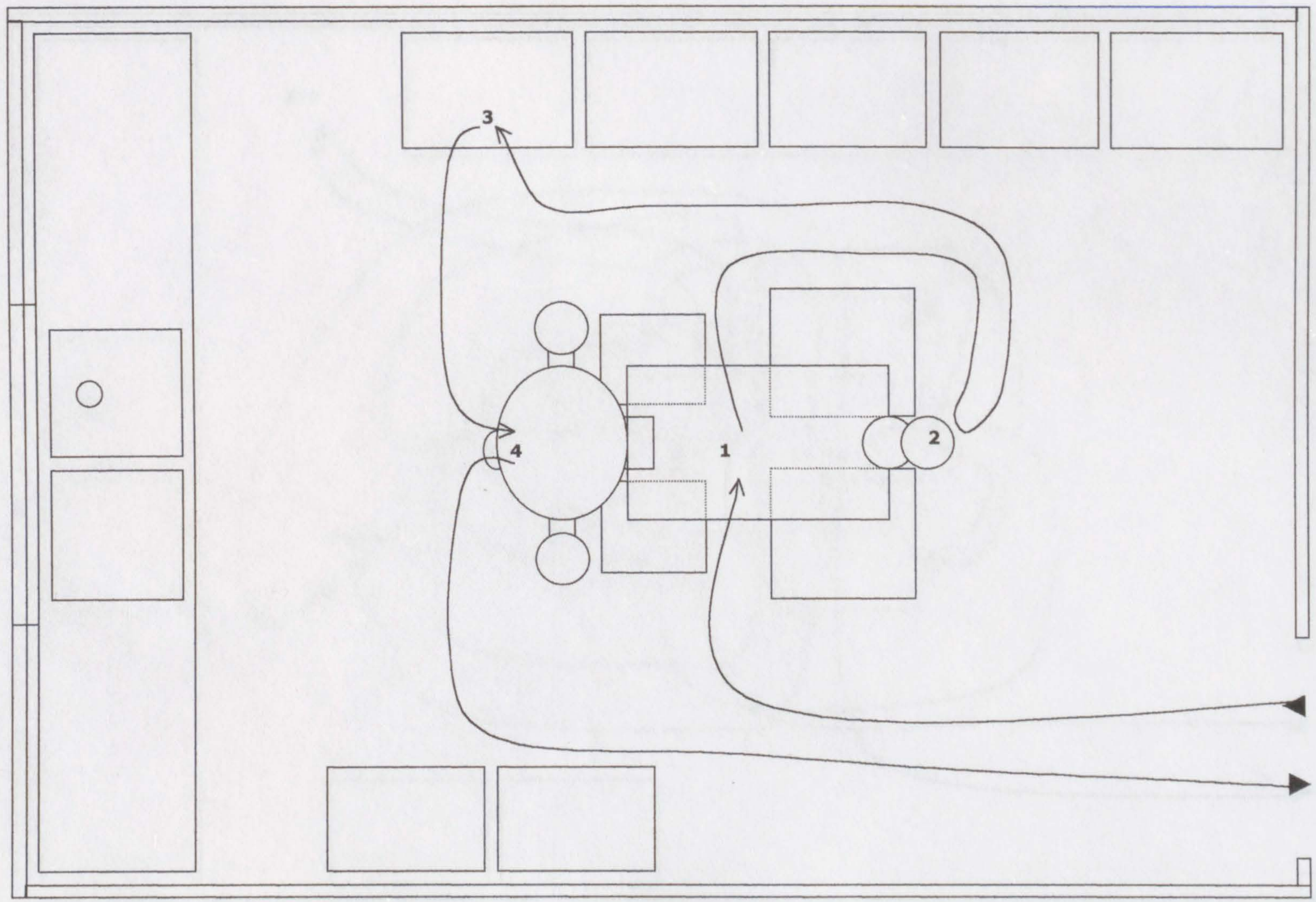
Date: *7.3.2001* ***Time:*** *10:20 – 10:35*

M. is very cheerful today, she comes in with Maggie. Maggie is talking to her as they come in 'Let's find a special toy for you to play with.' M. is attentive, Maggie brings her around when M. reaches out and touches the left horn. Maggie lets her explore talking and explaining to her, M. goes 'Ooooo', then she moves her around to the front and positions her in front of Zog's head, she helps M. touch both horns with both hands and she explains, 'There's one, there's two...' She helps her to explore the features of the face. M. has her hands on the face and she goes 'What's this... Ooooo'. She is touching the eye frames, the eye surfaces and then she pinches at the black eye centers. In the mean time Maggie leaves the room for a few minutes, I remain alone with M. M. understands Maggie is gone and she is with a stranger. I talk to her, she stops rocking, I tell her my name and she repeats my name, I assume we make friends. When Maggie returns, she helps her move around the right side and they sit on the floor. Maggie tells her 'Move your hands and let's see what you will come across', then she adds 'Does anything make a noise?' and she presses the sponge flower with 6 petals. When she presses it goes squeak, and she takes M.'s right hand to help her squeak it as well. As M. moves her hands the flower comes off its place, M. picks it up and explores it. Maggie asks her 'Can you put it back in its place?' M. seems puzzled and does not respond so Maggie leads her hands to the socket and they push it back in together. In the meanwhile there is noise from the water pipes, M. comments on it saying 'Someone turned on the tap.' She is rocking to and fro as she says this and her left foot hits the fabric-covered cube, the cube falls off its place with a jingling noise. Maggie asks her 'Oh, did you make a noise with your foot?' She moves M.'s foot over the cube again to make it jingle. 'Why was your foot making a noise?' She then moves M.'s left hand over to the cube and M. finds it, picks it up, shakes it. As it is tied to the leg, she shuffles her bottom to approach Zog, and keeps on shaking to hear the bell. She moves the cube to her right hand. Maggie says 'It's a nice noise', M. replies 'yeaa...'. Then she reaches her arm to the body and touches it, pats it and asks 'What's that?' Maggie replies 'Stand up and find out.' M. gets up by herself. She keeps on touching and patting leaning over the body. Maggie asks 'Is it soft?' 'Yes' 'Would you like to sit on it?' 'Yes' 'It's like a big seat.' Maggie helps her sit by lifting her up and telling her to put each leg on one side. She also helps her hold on to each horn for support. M. says 'Thank you.' Maggie asks 'Finished?' I ask if she would like the tail, Maggie helps her get off by herself. M. gets off the left side, and Maggie describes her the body 'Now this is the head, this is the body, and here he's got his tail,' she is also leading M.'s hands over these parts. Maggie leads her to the back, and M. asks for a cuddle. After the cuddle M. sits on Maggie's lap, 'I'm going to find out what this tail does, will you help me?' They pull together, 'longer, longer, longer... pull it hard again, do you think you can do it?' M. enjoys this and laughs. Maggie says 'It is wobbly, tickly.' M. plays at pulling the tail, and laughs, she starts singing and rocking to and fro as the tail wobbles back to its place. She plays a bit more with the tail. Then it is time to leave and Maggie asks her, 'Shall we go now?' M. replies 'No.' We laugh, and they both leave soon after.

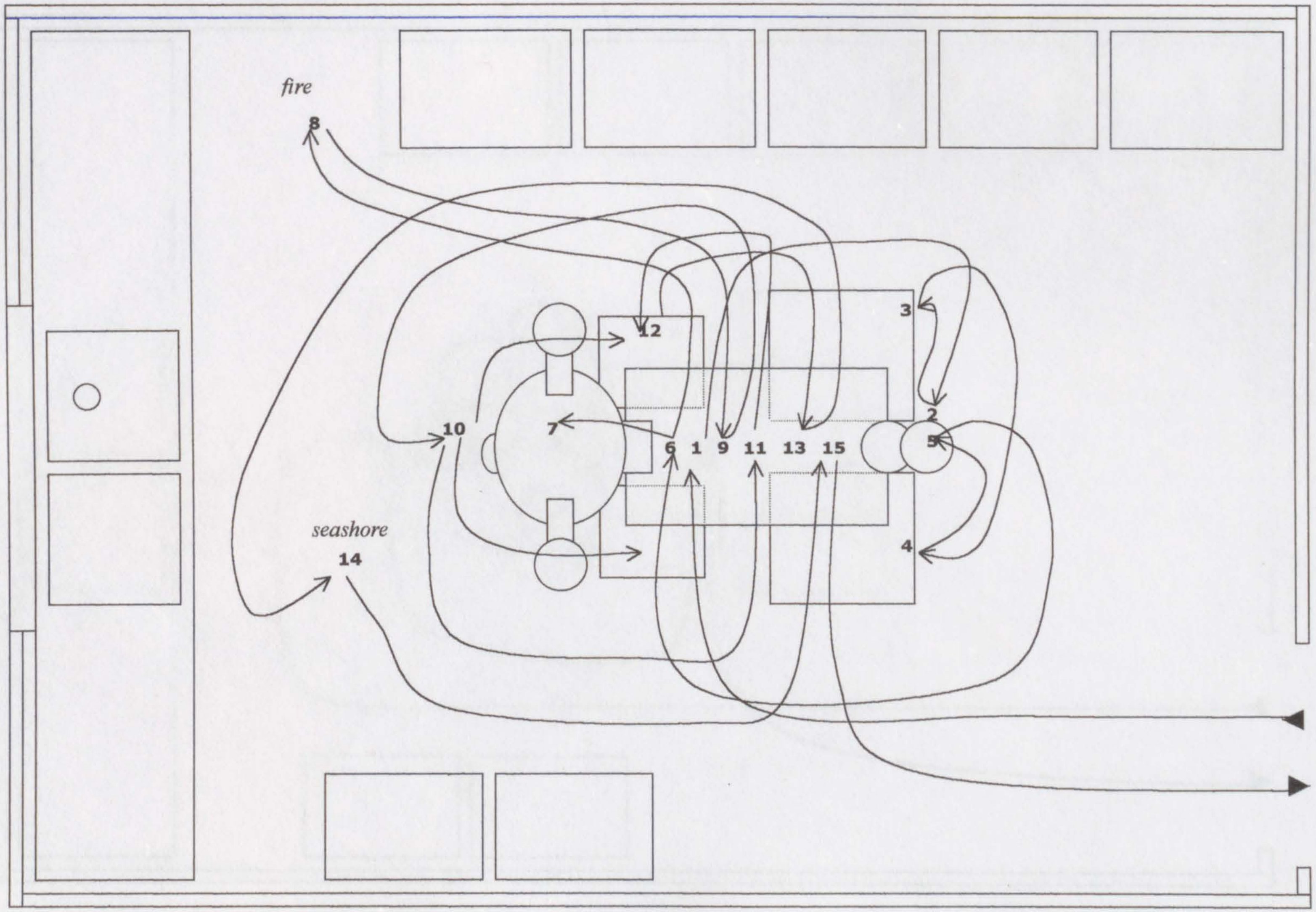
APPENDIX D

TRACKING SHEETS

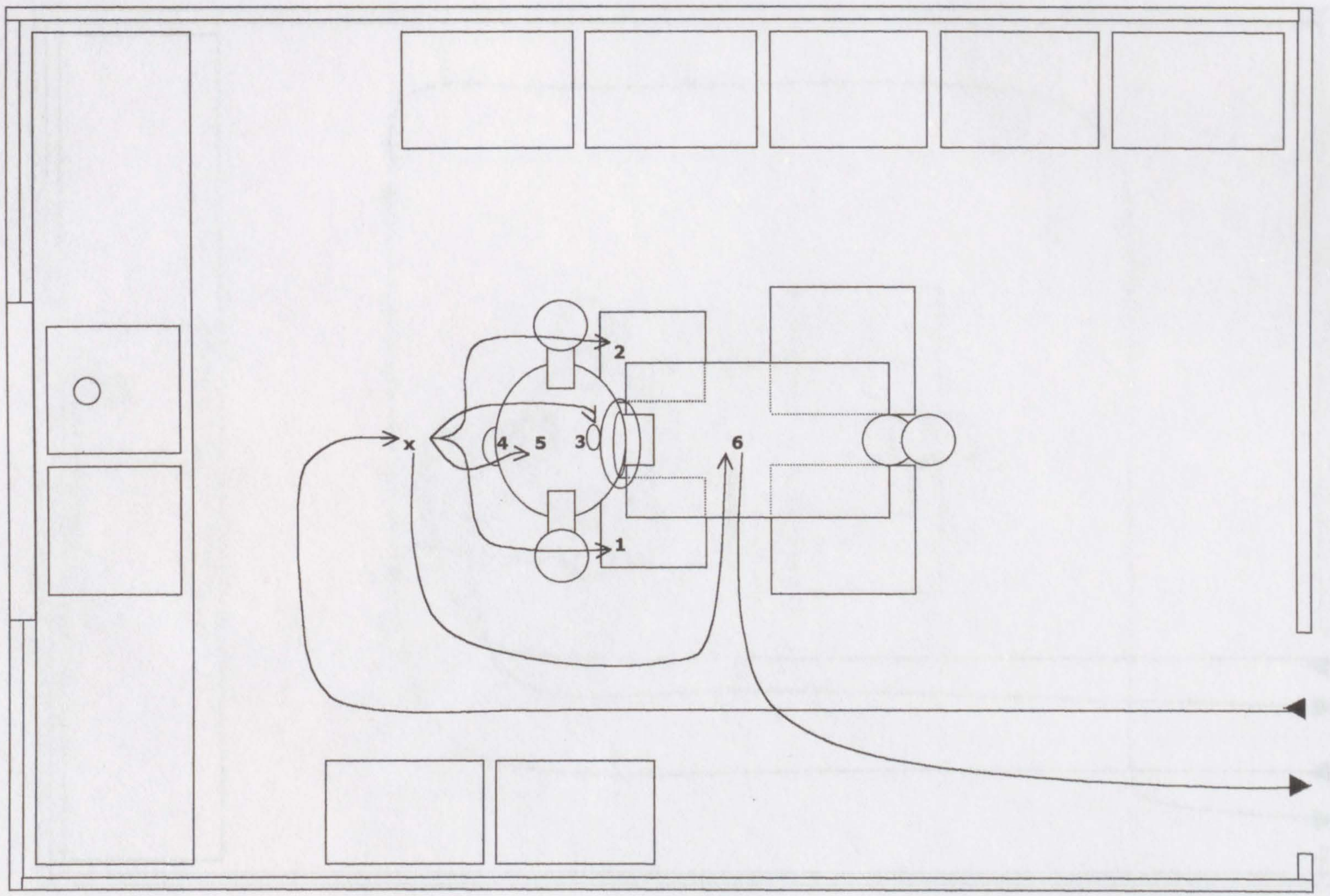
Child: C. (2 y, 9 m) ***Date / Time: 13.11.2000 / 10:15*** ***Total Time: 5 minutes***



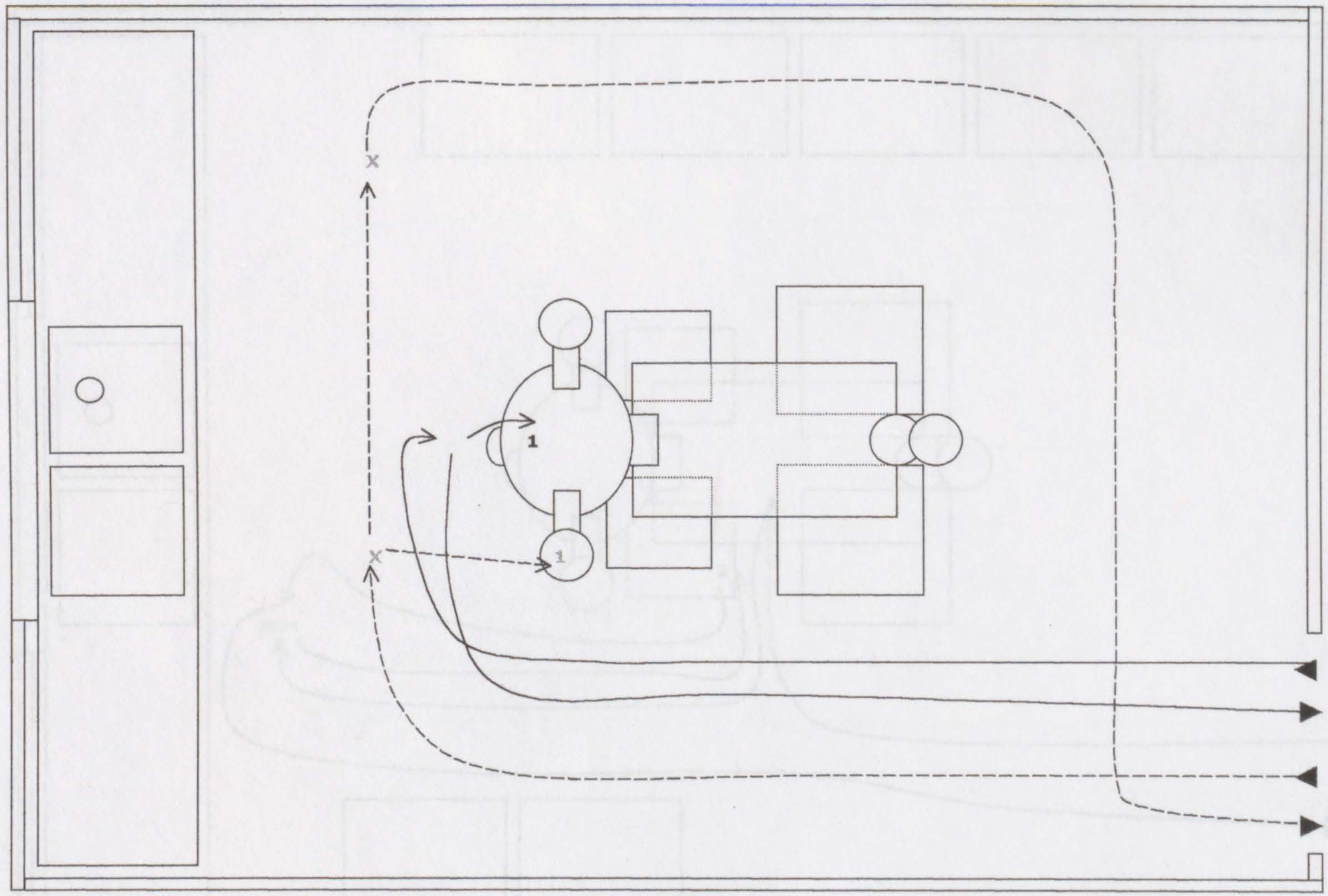
Child: C. (2 y, 9 m) **Date / Time: 20.11.2000 / 10:10** **Total Time: 15 minutes**



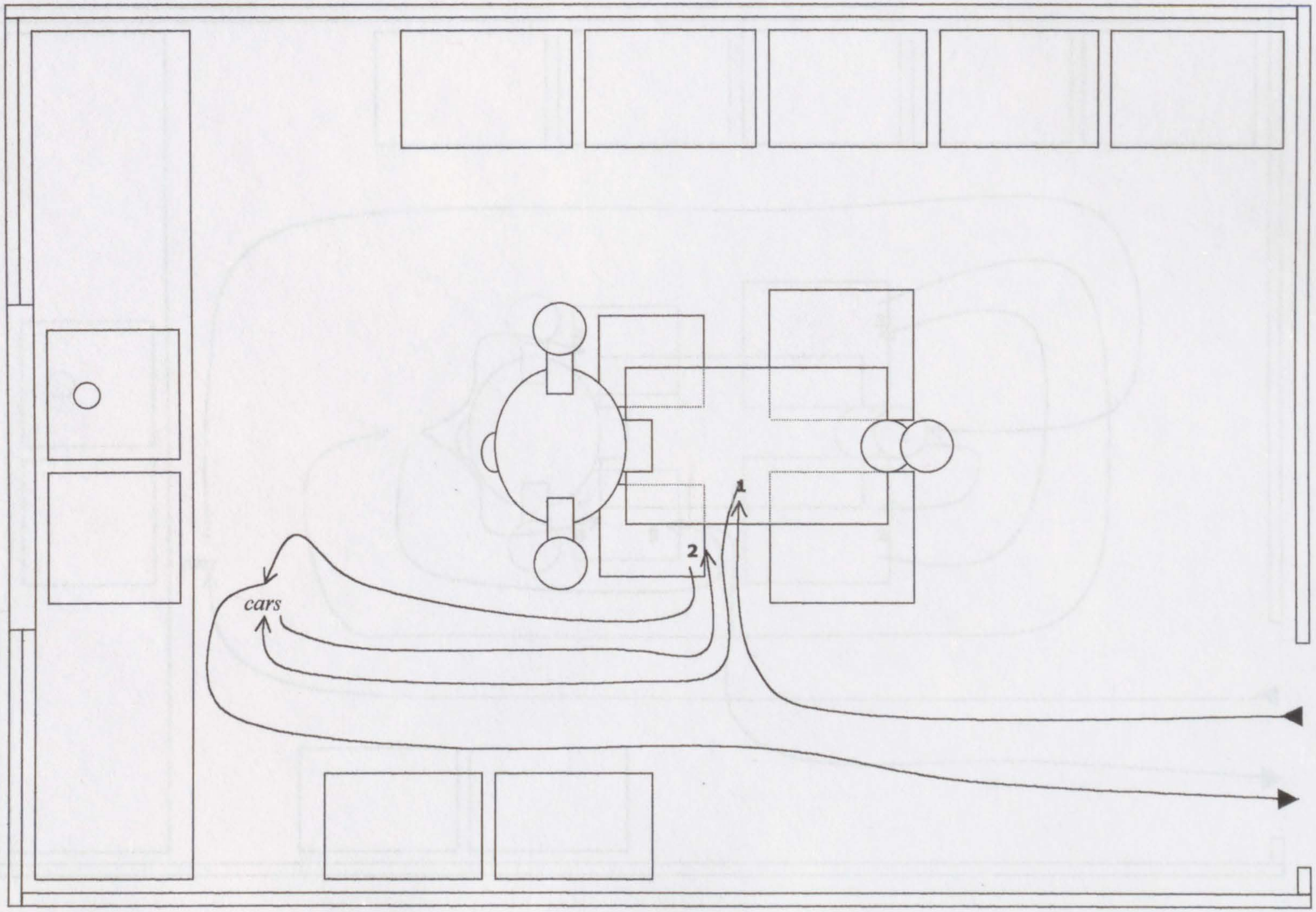
Child: J. (3 y, 1 m) Date / Time: 15.11.2000 / 10:15 Total Time: 7 minutes



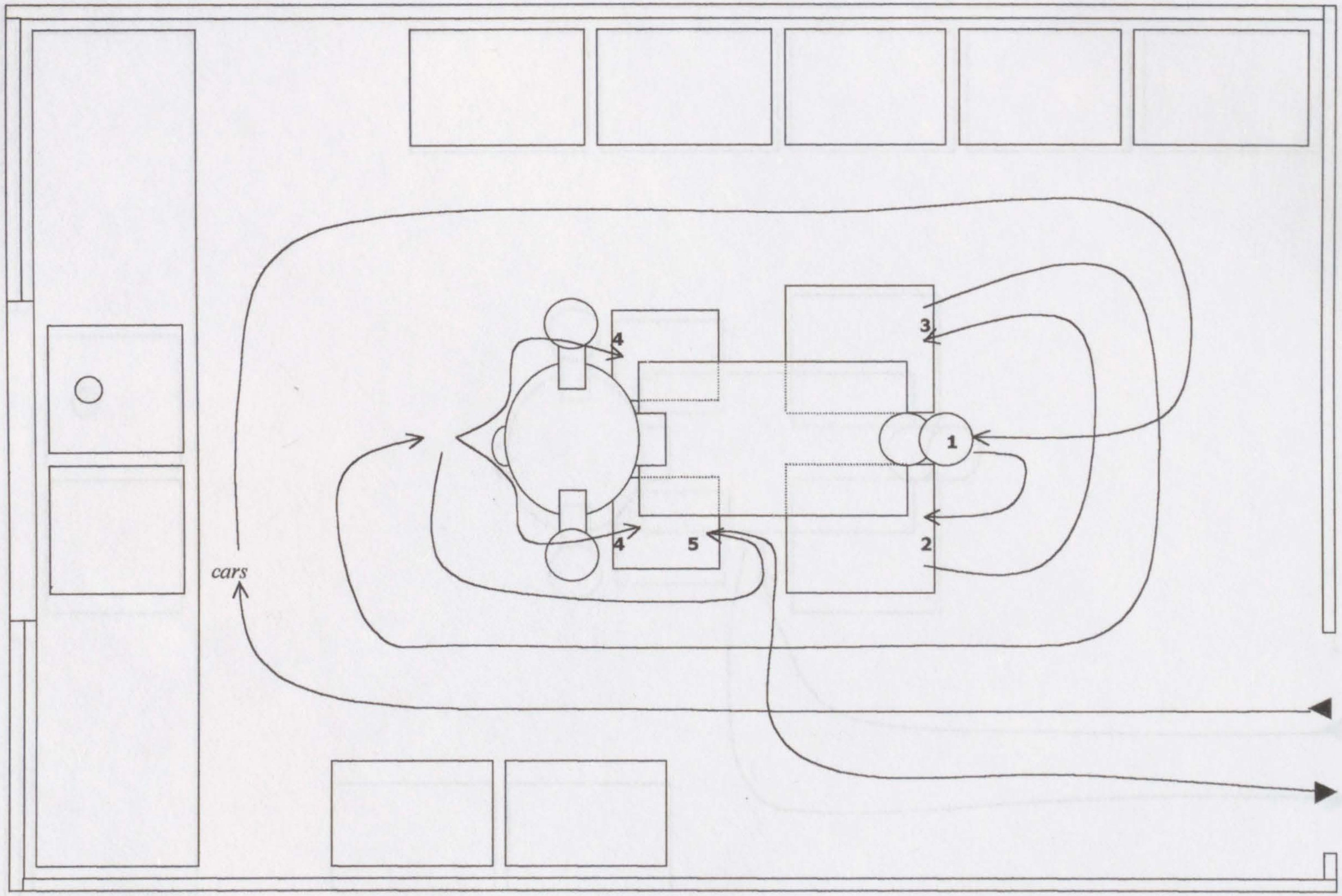
Child: J. (3 y, 5 m) | Date / Time: 7.3.2001 / 10:35 / 10:55 | Total Time: 2 / 3 minutes



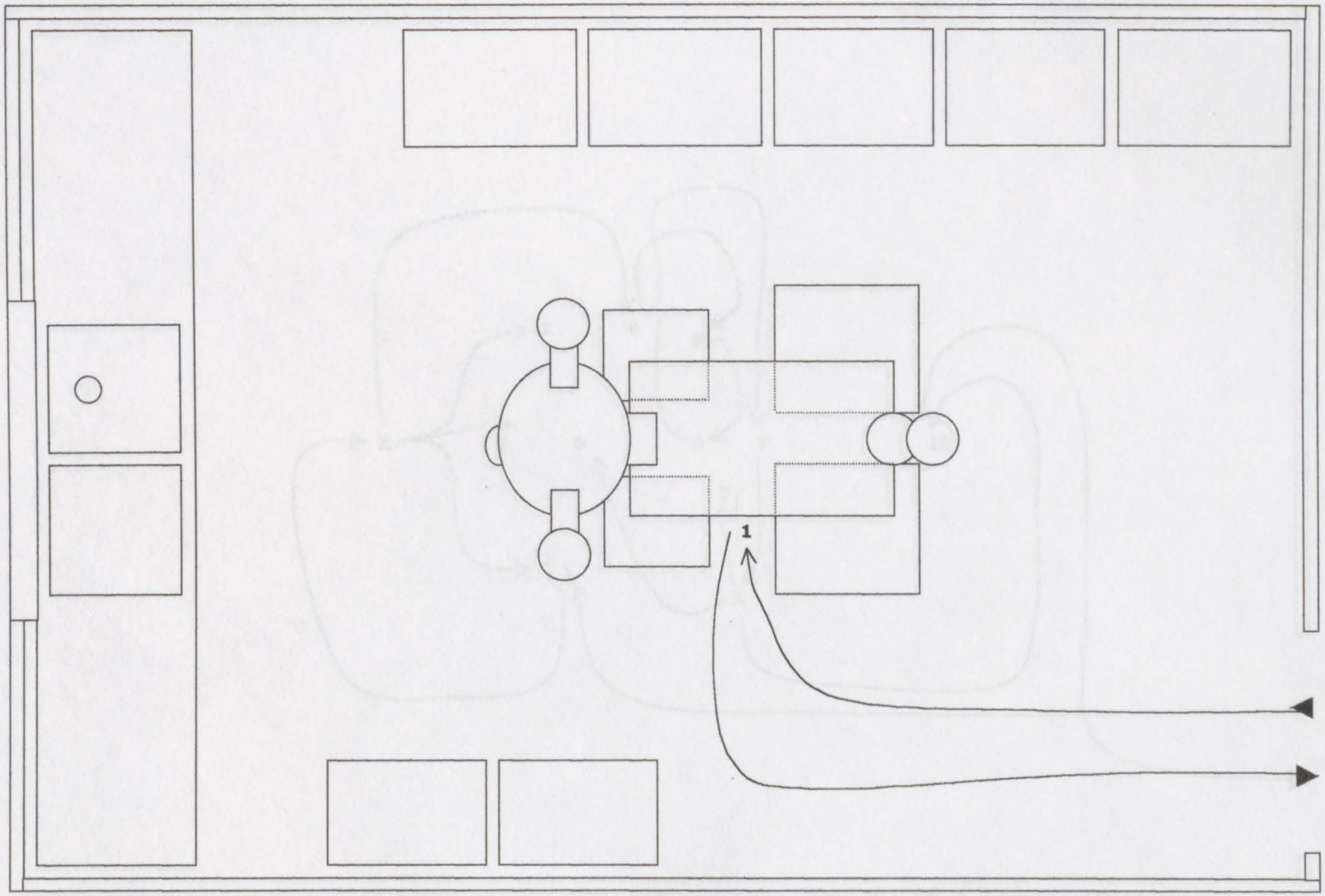
Child: R. (3 y, 3 m) **Date / Time: 16.11.2000 / 10:15** **Total Time: 10 minutes**



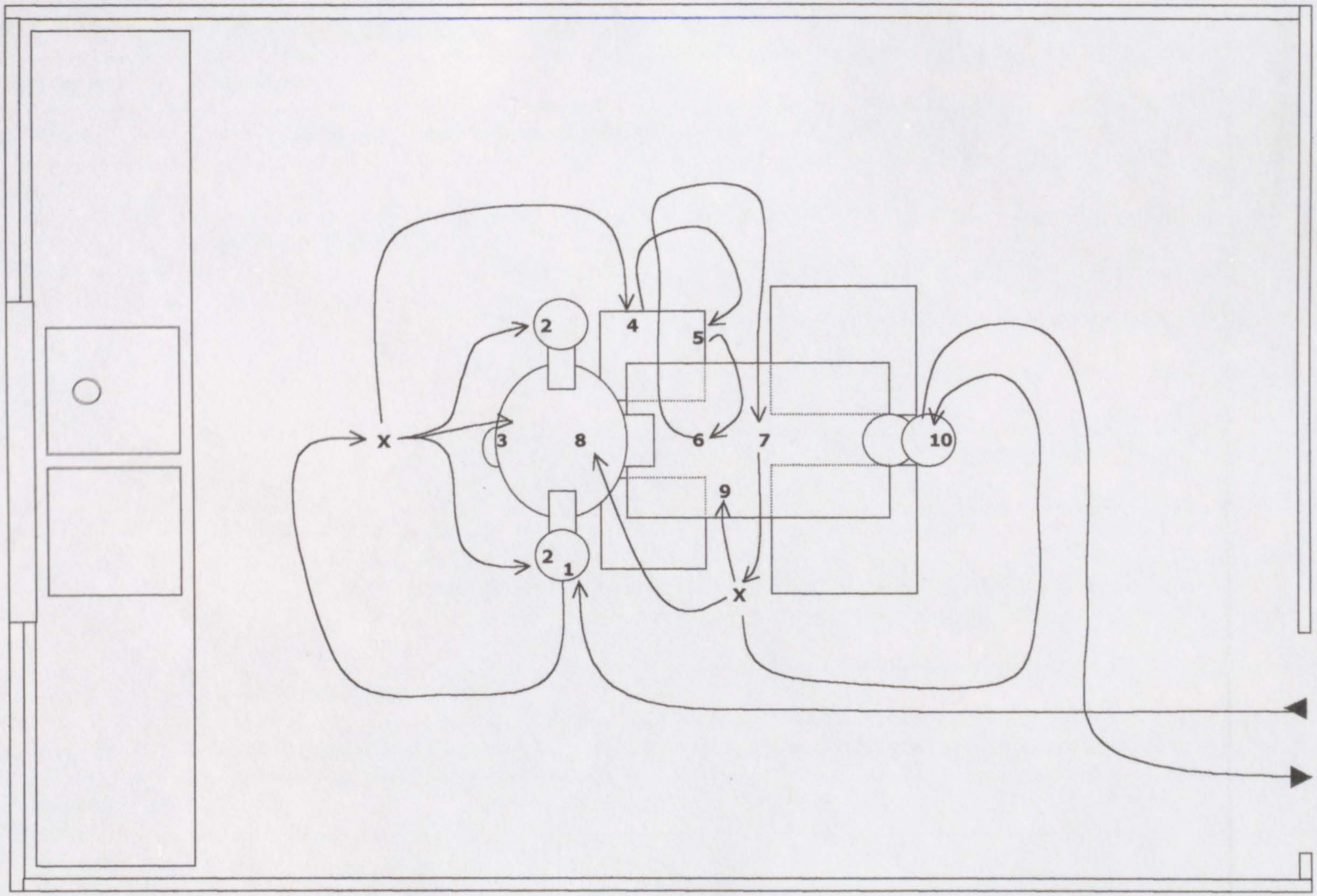
Child: R. (3 y, 3 m) **Date / Time: 23.11.2000 / 10:10** **Total Time: 10 minutes**



Child: M. (2 y, 11 m) *Date / Time: 22.11.2000 / 10:15* *Total Time: 4 minutes*



Child: M. (2 y, 11 m) *Date / Time: 7.3.2001 / 10:20* *Total Time: 15 minutes*



APPENDIX E

EVALUATION CHARTS

Child:C.

Session 1	**Date / Time: 13.11.2000 / 10:15 Total Time: 5 minutes**	
A. C / M of objects	√	only the tail
B. C / M of whole	√	climbs on – explores the face; moves around independently, searches for possibilities around the toy
C. Avoiding C / M	X	
D. Social with teacher	√	listens to encouragement
E. Imaginative play	X	
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	X	

Session 2	**Date / Time: 20.11.2000 / 10:10 Total Time: 15 minutes**	
A. C / M of objects	√	star, flowers, letters, basic shapes
B. C / M of whole	√	rides on, explores the head and tail; apart from using the space around Zog, uses spatial volume of the room to involve in his play
C. Avoiding C / M	X	
D. Social with teacher	√	involves teacher in the imaginative play
E. Imaginative play	√	imagines Zog to be a car, a fire engine, imagines the flowers to be a petrol cap, sea shells, and plays around these themes
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	X	

Child: J.

Session 1		***Date / Time: 15.11.2000 / 10:15 Total Time: 7 minutes***
A. C / M of objects	√	handles hard objects, the prisms
B. C / M of whole	√	explores the face, sits on Zog; only with the help of his teacher does he move around; spatially involved with his immediate surrounding
C. Avoiding C / M	√	avoids touching sponge objects
D. Social with teacher	√	is co-operative to the teacher's directives and encouragement
E. Imaginative play	√	plays 'pat the dog'
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	X	

Session 2		***Date / Time: 7.3.2001 / 10:35 / 10:55 Total Time: 2 minutes / 3 minutes***
A. C / M of objects	√	contacts features of the face
B. C / M of whole	X	
C. Avoiding C / M	√	although touches soft nose, does not touch sponge flower
D. Social with teacher	X	
E. Imaginative play	X	
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	X	

Child: R.

Session 1	**Date / Time: 16.11.2000 / 10:15 Total Time: 10 minutes**	
A. C / M of objects	X	does not wish to explore, but operates the music buttons
B. C / M of whole	√	observes the body, listens to music leaning under; is active around the toy, but not to explore; is actively exploring the room
C. Avoiding C / M	X	
D. Social with teacher	√	listens to his teacher
E. Imaginative play	√	says Zog is a duck, then says it is a car, says 'bye bye' to 'woof woof' as he leaves room
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	X	

Session 2	**Date / Time: 23.11.2000 / 10:10 Total Time: 10 minutes**	
A. C / M of objects	√	pulls the tail, contacts the letters, manipulates the flashing star, manipulates the square prism
B. C / M of whole	X	but moves around Zog to explore with the prompts of his teacher; moves in the room to search for cars
C. Avoiding C / M	X	his first reaction is to say 'no' but does contact objects when asked
D. Social with teacher	√	listens to the encouragement of his teacher, co-operates with her to explore an object or feature
E. Imaginative play	X	busy in exploring rather than to search for imaginative ways of playing
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	√	pokes his eye as he comes in, tends to poke his eye with the flashing star

Child: M.

Session 1	Date / Time: 22.11.2000 / 10:15 Total Time: 4 minutes	
A. C / M of objects	X	
B. C / M of whole	X	only to lean on the body to support herself standing
C. Avoiding C / M	√	refuses any contact
D. Social with teacher	X	refuses any encouragement or co-operation, babbling and not talking
E. Imaginative play	X	
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	√	rocks to and fro, stamps, babbles (stress)

Session 2	Date / Time: 7.3.2001 / 10:20 Total Time: 15 minutes	
A. C / M of objects	√	explores the horns, the facial features, the sponge flower, the tail
B. C / M of whole	√	explores the head, the body and the tail as parts of a whole with the encouragement of her teacher; is much more active around Zog compared to three months ago, and can stand up and get off the toy by herself to explore further
C. Avoiding C / M	X	
D. Social with teachers	√	co-operative, self expressive, talkative
E. Imaginative play	X	but sings along as she plays with the tail
F. Repetitive/inappropriate play	X	
G. Self-stimulating behaviour	√	rocks to and fro as she shakes the fabric covered cube; rocks as she touches the vibrating tail; rocks as she sings (pleasure)