Design decision-making by children aged 12-15 within design and technology education

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DESIGN DECISION-MAKING BY CHILDREN AGED 12-15 WITHIN DESIGN AND TECHNOLOGY EDUCATION

By

ALEXANDROS METTAS

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for
The award of

Doctor of Philosophy
Of Loughborough University

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## Contents

- LIST OF FIGURES ................................................................................................................................. vi
- LIST OF TABLES ........................................................................................................................................ vii
- ABSTRACT .................................................................................................................................................... x
- ACKNOWLEDGEMENTS ............................................................................................................................ xi
- LIST OF PUBLICATIONS ........................................................................................................................... xii

### CHAPTER 1: INTRODUCTION .................................................................................................................. 1

1.1 BACKGROUND TO THE RESEARCH ................................................................................................. 1
1.2 RESEARCH QUESTIONS ....................................................................................................................... 2
1.3 THE CONNECTION BETWEEN THE LITERATURE REVIEW AND THE RESEARCH QUESTIONS .... 3
1.4 AIMS OF THE STUDY .......................................................................................................................... 4
1.5 OBJECTIVES OF THE STUDY .............................................................................................................. 4
1.6 JUSTIFICATION FOR THE RESEARCH ............................................................................................. 5
1.7 CONTRIBUTION TO NEW KNOWLEDGE ........................................................................................... 6
1.8 PERSONAL MOTIVATIONS ................................................................................................................... 7
1.9 RESEARCH METHODOLOGY ............................................................................................................... 7
1.10 OUTLINE OF THE REPORT ................................................................................................................ 8

### SUMMARY .................................................................................................................................................. 8

### CHAPTER 2: LITERATURE REVIEW ......................................................................................................... 9

2.1. DECISION-MAKING AS A HUMAN ACTIVITY .................................................................................. 9
2.2. ADULTS’ DECISION-MAKING LITERATURE ..................................................................................... 13
2.3. CHILDREN’S DECISION-MAKING LITERATURE ............................................................................. 15
2.4. RESEARCH FROM THE AREA OF PSYCHOLOGY AND COGNITIVE DEVELOPMENT ................ 17
2.4.1 BASIC ELEMENTS OF PIAGET’S THEORY ..................................................................................... 18
2.4.1.1 THE STAGES OF OPERATIVE DEVELOPMENT ....................................................................... 19
2.4.2 THE CURRENT STATUS OF PIAGET’S THEORY ........................................................................... 21
2.4.3 VYGOTSKY’S SOCIAL CONSTRUCTIVISM ...................................................................................... 23
2.4.3.1 ZONE OF PROXIMAL DEVELOPMENT .................................................................................. 24
2.4.4 BRUNER’S THEORY ....................................................................................................................... 25
2.4.5 THE RELATIONSHIP OF PIAGET’S, VYGOTSKY’S AND BRUNER’S THEORIES ..................... 26
2.4.6 EDUCATIONAL IMPLICATIONS OF PIAGET’S, VYGOTSKY’S AND BRUNER’S THEORIES ...... 27
2.5. DECISION-MAKING IN EDUCATION ............................................................................................... 29
2.6. DECISION-MAKING IN DESIGN AND TECHNOLOGY EDUCATION ................................................ 30
2.7. KNOWLEDGE SKILLS AND VALUES IN DESIGN DECISIONS-MAKING ................................... 36
2.7.1 THE ROLE OF VALUES IN DESIGN DECISION-MAKING .............................................................. 38
2.7.2 THE ROLE OF KNOWLEDGE AND INFORMATION IN DESIGN DECISION-MAKING ........... 42
2.7.3. THE ROLE OF SKILLS IN DESIGN DECISION-MAKING ......................................................... 47
2.8. THE INFLUENCE OF SOCIETY IN DESIGN DECISION-MAKING ............................................... 49
2.9. TEACHERS’ ROLES IN CHILDREN DECISION-MAKING ............................................................ 52
2.10. CHILDREN’S DECISION-MAKING OPPORTUNITIES IN DESIGN AND TECHNOLOGY EDUCATION ......................................................................................................................... 56
2.11. THE ROLE OF THE CURRICULUM IN CHILDREN’S DECISION-MAKING ................................ 60
2.12. TRANSFER OF DESIGN DECISION-MAKING SKILLS .................................................................. 62
7.5.1 CHILDREN ENGAGEMENT AND CLASSROOM ACTIVITIES .......................................................... 220
7.5.2 CHILDREN’S ENGAGEMENT AND SOURCES OF INFORMATION .............................................. 221
7.5.3 THE BALANCE OF CONTROL BETWEEN TEACHER AND PUPIL ........................................... 222
SUMMARY ........................................................................................................................................ 223

CHAPTER 8: CONCLUSIONS .............................................................................................................. 224

8.1 CONCLUSIONS AND IMPLEMENTATIONS .................................................................................. 224
8.2 RESEARCH STUDY CONTRIBUTION TO KNOWLEDGE .......................................................... 229
8.3 FURTHER RESEARCH ................................................................................................................ 229

REFERENCES .................................................................................................................................... 232

APPENDICES ...................................................................................................................................... 269

ANNEXES ........................................................................................................................................... 293
List of Figures

Figure 2.1 - The design decisions pentagon (Barlex, 2005) .......................................................... 33
Figure 2.2 - Design decision heptagon (Trebell, 2011, p.29) ...................................................... 34
Figure 2.3 - Design and echnology as the outline of knowledge, skills and values (Norman, 2000, p.129).................................................................................................................. 37
Figure 2.4 - Restructuring of designerly knowledge (Layton 1993)................................................. 47
Figure 2.5 - Model of teaching and learning (Hallam and Ireson, 1999, p. 79).............................. 54
Figure 2.6 - Taken from the CReTE ‘teacher knowledge’ tool (Banks et al., 2004 p.143) .......... 56
Figure 2.7 - A simple model of formative interactions (From Black, 2008, p. 22) ...................... 58
Figure 2.8 - The balance of control between teacher and pupil in Year 7 project (from Stables, 1995, p.165).................................................................................................................. 59

Figure 3. 1 - Action research cycle (based on Zuber-Skerritt, 1992: 13) ....................................... 71
Figure 3. 2 - Action research plan on the development of decision- making skills ..................... 74
Figure 3. 3 -The Design of the pilot study .......................................................................................... 76
Figure 3. 4 - The design of the main study .......................................................................................... 79
Figure 3. 5 - Example of Pre-Test and Post-test ............................................................................. 92
Figure 3. 6 - The grounded theory analytic process (adapted from Harwood, 2002 p.76) ........... 95

Figure 4. 1 - Examples of boys’ and girls’ projects during the pilot study ................................... 113

Figure 5.1 - Example of log-book analysis ....................................................................................... 141
Figure 5.2 - Observation analysis sample ........................................................................................ 146
Figure 5.3 - Classroom activities for each year group from observations ..................................... 147
Figure 5.4 - The balance of control between teacher and children ................................................ 148
Figure 5.5 - Children’s engagement for each year group from observations ............................... 149
Figure 5.6 - Sources of information for each year group from observations ............................... 150
Figure 5.7 - Types of criteria for each year group from observations ............................................. 151
Figure 5.8 - Example of pre-test and post-test analysis................................................................. 155
Figure 5.9 - Example of pre and post-test analysis for task 2 ..................................................... 159

Figure 7.1 - Knowledge, skills and values as factors involved in children decision-making 175
Figure 7.2 - The role of teachers in children’s decision-making ................................................... 178
Figure 7.3 - Factors affecting children’s decision-making ............................................................. 186
Figure 7.4 - Model for factors affecting children’s decision-making in design and technology 188
List of Tables

Table 3. 1 - Characteristics of the sample of pilot study ......................................................... 78
Table 3. 2 -Pilot study data collected ......................................................................................... 78
Table 3. 3 - Data collection data collected for research questions .............................................. 82
Table 3. 4 - Data collection planed for the main study .............................................................. 82
Table 3. 5 - Design projects for each year group .................................................................... 87
Table 3. 6 - Grounded theory analysis analysis stages .............................................................. 96

Table 4. 1 - Example of interview coding .................................................................................. 99
Table 4. 2 - Example of the transformation of concepts into categories .................................. 100
Table 4. 3 - Type of tasks given to children’s by teachers ......................................................... 100
Table 4. 4 - Teachers’ difficulties in applying the requirements of curricula ............................ 101
Table 4. 5 - Teachers’ ideas on how children search for information for their design work ...... 101
Table 4. 6 - Type and importance of sources of information that children use ......................... 102
Table 4. 7 - The effect of books in children’s decision-making ................................................ 102
Table 4. 8 - The ability to set appropriate assessment criteria for their decisions .................... 103
Table 4. 9 - Lack of motivation faced by children according to teacher views ....................... 103
Table 4.10 - Teachers’ views on the ability of children to transfer the skills from design and technology to other every day activities ........................................................................... 104
Table 4.11 – Example of analysis of National Curriculum ......................................................... 105
Table 4.12 - Objectives from the Cypriot National Curriculum (2006) .................................... 106
Table 4.13 - Objectives from the English National Curriculum (2004) .................................. 107
Table 4.14 - Objectives from the Icelandic National Curriculum (2004) ............................... 108
Table 4.15 - Children’s views on the use of their prior experiences in their next decisions ...... 109
Table 4.16 – Peers’ influences in children’s decision-making in design and technology ......... 110
Table 4.17 - Children’s sources of information ...................................................................... 110
Table 4.18 - Difficulties in setting appropriate assessment criteria .......................................... 111
Table 4.19 - Children’s ideas on their ability to transfer their skills from design and technology to other areas of life ............................................................................................ 111
Table 4.20 - Example of the coding of children’s log-books ..................................................... 112
Table 4.21 - Children’s reasons for choosing a certain topic from log-books ............................ 113
Table 4.22 - Sources of information mentioned by children in their log-books ...................... 114
Table 4.23 - Children’s sources of information from log-books .............................................. 114
Table 4.24 - Children’s codes in relation to the possibility that a decision taken in one area will affect the decision taken in the forthcoming decisions of the project ........................................ 115
Table 4.25 - Children’s beliefs about how one design decision might affect the next decisions in the same project. ........................................................................................................ 115
Table 4.26 - Sample of the pilot study observation .................................................................. 116
Table 4.27 - Children’s sources of information observed during the pilot study. .................. 117
Table 4.28 - Task 1 information given to children ......................................................... 117
Table 4.29 - Children’s responses in task 1 ................................................................. 118
Table 4.30 - Task 2: information given to children ...................................................... 118
Table 4.31 - Children’s responses in task 2 ................................................................. 118
Table 4.32 - Task 3: information given to children ...................................................... 119
Table 4.33 - Children’s responses in task 3 ................................................................. 119
Table 4.34 - Task 4 - information given to children ..................................................... 119
Table 4. 35 - Children’s responses in task 4 ............................................................... 120
Table 4. 36 - Emerged categories from the pilot study ............................................... 123

Table 5.1 - Categorization of children within different age groups ............................. 128
Table 5.2 - Example of interview analysis ................................................................. 129
Table 5.3 - Sources of information from the pre-observational interviews ..................... 130
Table 5.4 - Children’s evaluation criteria from pre-observational interviews ............... 131
Table 5.5 - Relative Importance of the Criterion from Pre-observational Interview .......... 132
Table 5.6 - Children’s decision-making opportunities from pre-observational interview .... 133
Table 5.7 - Transfer of skills from pre-observational interview .................................... 134
Table 5.8 - Sources of information from post-observational interview ......................... 136
Table 5.9 - Children’s evaluation criteria from post-observational interviews .............. 137
Table 5.10 - Children’s decision-making opportunities from post-observational interviews ... 138
Table 5.11 - Factors affecting children’s decision-making from post-observational interview ... 140
Table 5.12 - Number of children’s alternative choices from log-books ....................... 142
Table 5.13 - Children’s evaluation criteria from log-books ...................................... 143
Table 5.14 - Sources of information from children’s log-books .................................. 144
Table 5.15 - Children’s responses if decision will or will not affect forthcoming decisions from log-books ........................................................................................................ 145
Table 5.16 - Classroom Activities for each year group from observations ..................... 147
Table 5.17 - Children’s engagement in decision-making activities from observations ... 149
Table 5.18 - Sources of information from the observations ....................................... 150
Table 5.19 - Children’s types of criteria from observations ........................................ 151
Table 5.20 - Types of design decisions from the observation ..................................... 152
Table 5.21 - Decision-making strategies observed ...................................................... 153
Table 5.22 - Decision-making difficulties observed .................................................... 153
Table 5.23 - Reasons for choosing a location for the power station from pre-test and post-tests ........................................................................................................ 156
Table 5.24 - Sources of information from pre-test and post-tests ............................... 157
Table 5.25 - Importance of criteria from pre and post tests ....................................... 158
Table 5.26 - Reasons for choosing a mobile phone from pre-test and post-tests .......... 160
Table 5.27 - Sources of information from pre-test and post-tests ............................... 161
Table 5.28 - Importance of each criterion from pre-test and post-tests ...................... 162

Table 6.1 - Research questions of the study ............................................................. 164
Table 6.2 - Data collected for each research question.................................................................165

Table 7.1 - Children’s sources of information identified from the main research.......................202
Table 7.2 - Children evaluation criteria identified from the main research.................................211
Table 7.3 - Student engagement and Interest vs. classroom activities ........................................220
Table 7.4 - Student engagement vs. sources of information.......................................................221
ABSTRACT

PhD

DECISION-MAKING BY CHILDREN AGED 12-15 WITHIN DESIGN AND TECHNOLOGY EDUCATION

The thesis presents research regarding decision-making by children aged 12-15 within design and technology education. An in depth discussion of the factors that are affecting children’s decision-making capabilities in design decision-making as found in the previous literature is presented. The literature provides information on children’s and adults’ decision-making processes, research from the area of cognitive development, the implementation of decision-making in educational contexts, the role of teachers and curriculum materials, and the role of knowledge, skills and values within design decision-making. These were reviewed as part of the theoretical background of the study.

An action research methodology was designed in order to gather data relevant to children’s decision-making behaviour. A pilot study was conducted to explore the spontaneous strategies that children follow in order to take their design decisions. Based on the results of the pilot study, the research methodology was redesigned and a main study was conducted. Three age groups from 12 to 15 were included in the sample of the study and 15 children were interviewed before and after a design task was given to them. Additionally 110 children were observed while designing, their log-books were analysed and they completed pre-tests and post-tests with activities relevant to decision-making.

The results of the study were analysed using grounded theory guidelines and the key findings are discussed. Based on the findings of the research study a model was designed that describes the factors that are involved in children’s decision-making in design and technology education. From the results of the study children’s strategies, difficulties they faced, their age, the requirements of curriculum materials and teachers’ pedagogical activities seemed to affect children’s decision-making behaviour. Finally the thesis discusses these results in relation to the original research questions and also presents some suggestions for further work.

Alexandros Mettas
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I would like to say a big ‘Thank you’ to all the people (children and teachers) and schools who agreed to be participants for this research in some form or another. Without their efforts there would be no data to discuss and no findings to find.

Finally I would like to thank my family and my friends for their encouragement and support. It would have been impossible without them.
List of Publications


Chapter 1: Introduction

Overview: Chapter 1 introduces the research study and describes its aims in relation to children’s design decision-making. The Chapter gives information on the background of the research, its contribution to new knowledge, the research questions and an overview of the research design.

1.1 Background to the Research

Decision-making is one of the fundamental processes that humans continuously go through in their everyday life. From a very young age people make various decisions daily or select from available or created options (Zoller, 1982). Hence, children development of decision-making skills should be an objective of educational systems all over the world (Clemen, 1991).

According to Zoller (1982) decision-making is identifying and choosing alternatives based on the values and preferences of the decision-maker. Making a decision implies that there are alternative choices to be considered, and in such a case the decision-maker identifies as many of these alternatives as possible and choose the one that (a) has the highest probability of success or effectiveness and (b) best fits with its goals, desires, lifestyle and values.

According to Kortland (1996) decision-making process is a course of actions of sufficiently reducing uncertainty and doubt about alternatives to allow a reasonable choice to be made from among them. Zoller (1982) points out that during decision-making process uncertainty is reduced rather than eliminated. Very few decisions are made with absolute certainty because complete knowledge about all the alternatives is seldom possible. Thus, every decision involves a certain amount of risk (Jimenez-Aleixandre and Pereiro-Munoz, 2002).

Every decision is made within a decision environment, which is defined as the collection of information, alternatives, values, and preferences available at the time of the decision. An ideal decision environment would include all possible information, all of it accurate with every possible alternative. However, in practice both information and alternatives are constrained because the time and effort to gain information or identify alternatives are limited. Since decisions must be made within this constrained environment decision-making is a complex cognitive process with many factors involved in it (Kahneman and Tversky, 2000).
Despite the significance of decision-making as a vital activity in human behaviour there is little research available that explains that phenomenon. In the field of educational research, children’s decision-making strategies have only recently gained significant attention. There are few research studies that look at various aspects of decision-making in the area of design and technology education (Barlex, 2007a; Barlex and Rutland, 2004; Coles and Norman, 2005; Davies, 2004; Mettas and Constantinou, 2008; Mettas, Thorsteinsson and Norman, 2007).

Some research outcomes that come from the area of cognitive development (Davidson, 1991a, 1991b; Klaczynski, Byrnes, and Jacobs, 2001) or operational management (Bazerman, 2005; Hammond, Keeney and Raiffa, 1999) can also be related to the teaching and learning of children’s decision-making skills.

The improvement of children’s decision-making skills needs to be examined in more detail within the school environment. Therefore it is important for teachers to support and guide children to develop decision-making skills (Mettas and Norman, 2008). Design and technology education provides an effective framework where decision-making skills can be enhanced through design and make activities. In design and technology education, decisions include all the actions that a child (as a designer) will accomplish in order to choose their best perceived action among alternative design decisions. Developing children’s decision-making capability would make a significant link between the work of children in design and technology classrooms and their everyday decisions outside school.

Children’s decision-making analysis is a complex process that is possible to be influenced from many factors. Within the school environment teachers and curriculum materials play a central role in the development of decision-making skills. At the same time society may have an effect on children’s decision-making process. From some research studies it can be concluded that decisions involves knowledge, skills and values and design decisions are often taken with their influence (Coles and Norman, 2005; Hicks et al., 1982).

### 1.2 Research Questions

This study attempts to explore different aspects of children’s decision-making strategies in design and technology education. Because of the complexity of decision making as a process the research questions are enrich with some sub-questions in order to explore in more detailed this phenomenon. Specifically, the research questions and sub-questions that will guide this study are the following:
1. What types of decisions do teachers expect secondary education children (12-15 years old) to engage in during different parts of designing and making?
   a. What decision-making opportunities are included in design and technology curricula?
   b. What decision-making opportunities do teachers give to children when working on design and technology activities?

2. What strategies do secondary education children follow in order to make their design choices?
   a. What types of sources of information do secondary education children prefer when making a technological decision?
   b. Do the sources change as the children grow older?

3. What are the difficulties that secondary education children face in their efforts to make decisions in their designs?
   a. What is the ability of children to develop criteria for evaluating options?
   b. Do the evaluation criteria change as the children grow older?

4. To what extent can decision-making skills learnt within the area of design and technology be transferred to other activities?
   a. Does experience in design and technology improve the children’s capabilities in making decisions in other situations such as personal/social dilemmas (such as environmental issues, personal/public purchasing, genetic engineering, biotechnology etc.)?
   b. Are children more able to transfer decision-making skills in personal/social dilemmas as they grow older?

1.3 The Connection between the Literature Review and the Research Questions

Teachers’ roles in teaching decision-making strategies (research question 1) to children are largely unexplored throughout the literature. There are some studies within the available literature discussing various aspects of decision-making of children that are mainly coming from the area of cognitive development. Some of them are related to possible difficulties and strategies children face during decision-making (research questions 2 and 3) but none of them are suggesting ways to overcome those difficulties through teaching and learning. Therefore, the research questions about the possible difficulties and the strategies that children engage in during decision-making in design and technology will improve our understanding of that area.
Literature on the ability of children to differentiate relevant from irrelevant information is very limited as well (research question 2). Some studies with younger children (ages 6-10) suggest possible strategies that children go through but there is less work with the study target age group (ages 12-15).

There is no significant evidence within the literature about children’s ability to transfer their skills from one area to another (research question 4). Therefore outcomes about children’s ability to transfer their decision-making skills from design and technology education to other areas will mainly be gathered from the current research study.

1.4 Aims of the Study

The general aim of the study is to explore the factors that are involved in decision-making by children aged 12-15 within design and technology education. More specifically the aim of the study is to investigate:

- Teachers’ roles and the effects of curriculum on the decision-making opportunities that are given to children in design and technology education.
- Children’s design decision-making strategies in design and technology education in Cyprus.
- The sources of information that children use in order to build their knowledge before taking their design decisions.
- The difficulties that children face in their efforts to take their design decisions in design and technology education.
- The transfer of the decision-making skills that are learnt through design and technology education to other subjects such as environmental engineering or personal purchasing etc.

1.5 Objectives of the Study

Objective 1: To identify the types of decisions teachers expect secondary education children (12-15 years old) to engage in during different parts of designing and making.

The first objective is to identify the types of design decisions with which teachers expect children to be involved. The review of existing teaching materials and curricula that are in use internationally will set the starting point of the research. Teachers’ views on this issue will also
be explored in order to understand some specific aspects of practice. The outcomes will form a concrete background to the existing design decision-making expectations and opportunities for young children.

**Objective 2: To identify the strategies that secondary education children follow in order to make their design choices.**

The spontaneous decision-making strategies of children while they are facing design decisions will be identified. The main focus will be on the sources of information children rely on for their design decisions and if these sources change as children grow older.

**Objective 3: To identify the difficulties that secondary education children face in their efforts to make decisions in their designs.**

The possible difficulties that children face in their design decisions and the degree to which children’s designs might be affected will be explored. The focus will be on the children’s ability to develop criteria for evaluating their options and if the nature of difficulties during design decisions changes as the children grow older.

**Objective 4: To explore the extent to which decision-making skills learnt within the area of design and technology can be transferred to other activities.**

Children’s ability to transfer the decision-making skills developed through design and technology education to other personal/social dilemmas will be examined, and how that is related to their age.

### 1.6 Justification for the Research

Despite the importance of decision-making as a central and essential function in human behaviour and the frequency of its use, there is little research aimed at teaching children in design and technology education how to decide. In other words, children undergo almost no instruction which promotes their ability to choose from among several possible courses of alternative actions, even when they have full information about each choice.

Children’s understanding of decision-making strategies and their ability to transfer those skills in everyday activities are largely unexplored. Design and technology education teaching should
provide children with both the opportunity to apply their judgement in choosing among alternatives, and the experience to develop competence in this process.

Therefore a research study is needed in order to improve our understanding on children’s decision-making strategies used within design and technology education. The research outcomes will formulate the theoretical framework for the design of educational materials or teaching strategies that will seeks to improve children’s design decision-making.

1.7 Contribution to New Knowledge

This study will contribute to the theory regarding the decision-making strategies and difficulties that occur within the area of design and technology and will draw from that theory in order to design teaching material based on research evidence. More specifically the study aims to contribute to new knowledge on the following issues:

1. To understand the types of decisions that secondary education children (12-15 years old) follow during different parts of designing and making.
2. To describe the decision-making opportunities that are included in design and technology curricula which are suited to children’s capabilities.
3. To categorise the strategies that secondary education children follow in order to make their design choices.
4. To identify the sources of information that children prefer and trust when making a technological decision.
5. To understand if sources of information change as the children grow older.
6. To categorise possible difficulties that children face in their efforts to make decisions in their designs.
7. To identify to what degree children are able to develop criteria for evaluating options and how this changes with age.
8. To understand the extent to which decision-making skills learnt within the area of design and technology can be transferred to other activities.
1.8 Personal Motivations

As Elliot (1981) argues “At the heart of action research agenda is a personally focused concern” (quoted in Dadds, 1993, p.229). This study focuses on the work I decided to undertake into the development of children’s decision making strategies within the area of design and technology in Cyprus. I have been actively participating in the area of design and technology in various positions over the past eight years and had direct experiences as a teacher, in-service teacher trainer, pre-service teacher trainer and trainee.

During my teaching of design and technology to children I faced the complications in children’s decision-making strategies. Many children had difficulties in justifying their design decisions or even take a unique decision on their own. Discussing those feelings with other design and technology teachers, it became obvious that those difficulties about the development of children’s decision-making skills in Cyprus were quite common within the teacher community.

As an active teacher I have been searching for relevant literature in order to improve my understanding on those issues but unfortunately the available research on that area was very limited. This lack of research studies in such an important area of design and technology education sparked the current action I took for improvement. Through this research process I also aimed to develop his professional acumen in design and technology education (Cohen and Manion, 1994).

1.9 Research Methodology

To be able to explore children’s decision-making strategies in depth an action research study was designed. Action research is giving the opportunity to explore children’s decision-making skills in practice, in their own school environment and with their normal teacher. This kind of approach explores the phenomenon in its natural conditions without any external influences (McNiff and Whitehead, 2000).

For the purpose of this study, it was decided to use mainly qualitative methodology, although some quantitative methodology is also used in order to strengthen the results (Merriam, 2001). The study involves direct observations of the children in action and investigates how children brought their previous experiences to their design decisions.
A pilot study was designed as the initial cycle of the action research. Based on the results and the effectiveness of the pilot study a new action cycle was designed and applied in the main study of the research.

Data were collected through semi-structured interviews, semi-structured observations, children’s log-books, pre-tests and post-tests. The analysis of the pilot study data was based on grounded theory as there were not any pre-set assumptions for the outcomes. The data of the main study were analysed through the guidelines given by Miles and Huberman (1994) taking in mind the pre-set categories that were formulated from the analysis of the pilot study and the emergent categories that came out from the main study data.

1.10 Outline of the Report

To address the above general aim, the first phase of this study begins with the review of the literature on decision-making as a human activity with special references to children’s strategies (Chapter 2). Chapter 3 presents the research methodology of this study and the data collection methods. The results of the pilot studies are described next in order to give initial understanding on the outcomes of the study (Chapter 4). The results obtained from the main study were analysed and presented in Chapter 5. The report then is presenting the discussion and implementation of the outcomes of the study (Chapter 6) and ended up with several conclusions and suggestions for further research (Chapter 7).

Summary

Decision-making skills are an important part of our everyday activities. Therefore general education should give the opportunity to children to develop such skills. This research study will investigate how children acquired decision-making skills in design and technology education in Cyprus. As a starting point a review of the available literature on that issue will formulate the research background of the study.
Chapter 2: Literature Review

Overview: This Chapter is presenting a review of literature related to human decision-making. Children’s and adults’ decision-making processes, research from the area of cognitive development, the implementation of decision-making in educational contexts, the role of teachers and curriculum materials, the role of knowledge, skills and values within design decision-making and the history of design and technology in Cyprus are described as part of the theoretical background of the study.

2.1. Decision-making as a Human Activity

Decision-making is one of the fundamental processes that humans continuously go through in their everyday life. From a very young age people make various decisions daily concerning selection from available or created options. These decisions are often routine, inconsequential choices which they are barely aware of making, e.g. what to wear. Sometimes, these decisions are not clear-cut, although they may have a significant effect on us or others, e.g. whether or not to go to university or work. Sometimes decisions that appear fairly simple can be life changing, e.g. choosing to drive drunk (Clemen, 1991).

According to Baron (2000) “a decision is a choice of action of what to do or not to do. Decisions are made to achieve goals, and they are based on beliefs about what actions will achieve the goal. Decisions may be simple, involving only a single goal, two options, and strong beliefs about which option will best achieve the goal, or they may be complex, with many goals and options and with uncertain beliefs” (p.6).

Byrnes (1998) considers decision-making as a cognitive process that involves a number of component operations and cognitive processes. According to Byrnes (1998) taking a decision is not always something simple and may involve many complex processes and a good decision does not always lead to a good outcome. Often the quality of an individual decision cannot be measured in terms of its consequences because unexpected factors can ruin the outcome. Likewise, poor decision-making can be disguised by unusually good luck. For this reason Clemen and Gregory (1995) suggested that it is important to look at the process used to make a decision and determine whether that process has the characteristics of decision-making.
According to Richetti and Tregoe (2001), the nature of a decision and criticality of the outcome may differ, but each decision is characterized by the following elements:

- the need to make a choice between two or more possible courses of action;
- objectives or criteria that define a successful decision solution;
- consequences associated with each possible choice (p.2).

In the existing literature “rationality” refers to the decision-making process that is logically expected to lead to the optimal result. According to Bazerman (2005) “the rational model is based on a set of assumptions that prescribe how a decision should be made rather than describing how a decision is made” (p.6). Irrational decisions depend on intuitive biases that sometimes fail to see the full range of possible consequences. Bazerman (2005) pointed out that ‘decision-makers will forgo the best solution in favour of one that is acceptable or reasonable. Rather than examining all possible alternatives, they simply search until they find a solution that meets a certain acceptable level of performance’ (p.6).

Many researchers described a sequence of steps that could possibly guide rational decision-making (Bazerman, 2005; Birnbaum 1998, Garnham and Oakhill 1994; Hammond, Keeney and Raiffa, 1999). The steps or strategies that have been suggested have many similarities. The complexity of the process depends mainly on the proposed number of steps and in the mathematical relationships between steps. Those processes in decision-making are usually called “optimisation techniques” and are applied in order to improve the quality of the decision-making process.

Optimisation is an analytical framework that is commonly used in engineering in order to identify a best solution among a number of options. Mettas and Constantinou (2008) suggested that in some cases it can be used as a reasoning strategy that children can follow in design and technology education as a method for selecting an optimal solution among a number of options taking multiple criteria into account.

Byrnes, Miller and Reynolds (1999) proposed a four step optimization model for rational decision-making. The first step involves the setting of a goal (e.g. do well in an exam). The second step involves the compiling of options for producing the goal (e.g. studying, hiring a tutor). The third step involves the rank-ordering of options (e.g. studying is better than hiring a tutor). The last step consists of the selection of the highest-ranked option (Byrnes, 1998; Furby and Beyth-Marom, 1992).
Hammond, Keeney, and Raiffa (1999) suggested eight steps: (1) work on the right problem, (2) specify your objectives, (3) create imaginative alternatives, (4) understand the consequences, (5) grapple with your tradeoffs, (6) clarify your uncertainties, (7) think hard about your risk tolerance, and (8) consider linked decisions. Both of these lists provide a useful order for thinking about what an optimal decision-making process might look like.

Bazerman (2005) suggested six steps that the decision-maker should follow when applying a ‘rational’ decision-making process. The term rationality refers to the decision-making process that is logically expected to lead to the optimal result, given an accurate assessment of the decision-maker’s values and risk preferences.

1. Define the problem. Accurate Judgement is required to identify and define the problem.

2. Identify the criteria. Most decisions require the decision-maker to accomplish more than one objective. The rational decision-maker will identify all relevant criteria in the decision-making process.

3. Weight the criteria. Different criteria will be of varying importance to a decision-maker. Rational decision-makers will know the relative value they place on each of the criteria identified.

4. Generate alternatives. The fourth step in the decision-making process requires identification of possible courses of action.

5. Rate each alternative on each criterion. The rational decision-maker will be able to assess carefully the potential consequences of selecting each of the alternative solutions on each of the identified criteria.

6. Compute the optimal decision. The process of computing the optimal decision consists of (1) multiplying the ratings in step 5 by the weight of each criterion, (2) adding up the weighted ratings across all of the criteria for each alternative, and (3) choosing the solution with the highest sum of the weighted ratings (Bazerman, 2005, p.4).

The optimization processes proposed above are useful tools in that they ensure that a decision will be “rational”. However, such processes are not always possible for all decisions in everyday actions. There are cases that, because of time limitations or the difficulty of identifying all possible actions and their consequences, the use of optimisation or rational decision-making processes are unfeasible. In everyday activities not every action deserves extensive thought and analysis before taking action. In fact, many of our day-to-day activities require us to make
snap decisions. Part of becoming a good decision-maker is being able to identify those situations that deserve careful thought (Clemen, 1991).

Bazerman (2005) used the term “bounded-rationality” which refers to the obstacles that an individual might face in attempting to make rational decisions. According to Bazerman (2005) bounded-rationality “acknowledges that decision-makers often lack important information on the definition of the problem, the relevant criteria and so on. Time and cost constraints limit the quantity and quality of available information. Furthermore, decision-makers retain only a relatively small amount of information in their usable memory. According to Bazerman (2005) limitations on intelligence and perceptions constrain the ability of decision-makers to “calculate accurately the optimal choice from the information that is available” (p. 6). Those limitations prevent decision-makers from making the optimal decision through optimisation or rational decision-making processes.

Stanovich and West (2000) made a distinction between “System 1” and “System 2” cognitive functioning. System 1 thinking refers to our intuitive system, which is typically fast, automatic, effortless, implicit, and emotional. People make most decisions in life using System 1 thinking. By contrast, System 2 refers to reasoning that is slower, conscious, effortful, explicit, and logical (Kahneman, 2003). Bazerman’s (2005) logical steps above provide an example of System 2 thinking.

The busier and more rushed people are, the more they have on their minds, and the more likely they are to rely on System 1 thinking. A complete System 2 process is not required for every decision we make and in some cases is not possible anyway. In most situations, our System 1 thinking is quite sufficient; it would be impractical, for example, to logically reason through every choice we make while shopping for groceries. But System 2 logic should preferably influence our most important decisions. One key goal for decision-makers is to identify situations in which they should move from the intuitively compelling System 1 thinking to the more logical System 2 (Clemen, 1991; Stanovich and West, 2000).

Research studies have identified a number of simplifying strategies or rules of thumb in making decisions. These simplifying strategies are called “heuristics” (Gigerenzer, 2001; Tversky, 1972) and are relevant with Stanovich and West (2000) system 1 cognitive functioning. As the standard rules that implicitly direct our judgment, heuristics act as a mechanism for coping with the complex environment surrounding our decisions. Individuals may use simple rules for
decision-making when faced with complex decisions. Such heuristics reduce cognitive requirements by focusing the decision-maker on the most promising strategies (Kahneman, Slovic and Tversky, 1982).

Bazerman (2005) argued that heuristics are helpful, but their use can sometimes lead to severe errors during decision-making. He identified three main types of heuristics:

- The availability heuristic - people assess the frequency, probability, or likelihood of an event by the degree to which instances or occurrences of that event are readily “available” in memory. An event that evokes emotions and is vivid, easily imagined, and specific will be more available than an event that is unemotional in nature, bland, difficult to imagine, or vague.
- The representativeness heuristic – when making a judgement about an individual (or object or event), people tend to look for traits an individual may have that correspond with previously formed stereotypes.
- The affect heuristic – most of judgments are evoked by an affective, or emotional, evaluation that occurs even before any cognitive reasoning takes place. People nonetheless use them as the basis of their decisions rather than engaging in a more complete analysis and reasoning process (Bazerman, 2005, pp. 8-10).

2.2. Adults’ Decision-making Literature

Despite the importance of the development of decision-making skills and the decision-making approaches that are available, only a few research studies have explored how humans actually behave during decision-making and most of them used adults as participants (Byrnes, 1998). The majority of the studies are coming from the areas of operational research and marketing. These studies suggested that adults could progressively learn to make better decisions if they received relatively clear feedback from outcomes (Busemeyer and Myung, 1992; Hogarth, Gibbs, McKenzie and Marquis, 1991).

Much of the decision-making research with adults has explored what strategies they employ when making decisions (Payne, Bettman, and Johnson, 1993). A number of studies have found that some strategies involved an exhaustive search of the alternatives and their dimensions; other strategies involved making a decision without looking at all the available information (Klayman, 1985). Typically, decision analysts have suggested that optimal decision-making
behaviour involves making decisions after reviewing all available information that is relevant (Howse, Best and Stone, 2003)

According to Klayman (1985), there are two categories of decision-making strategies, high-processing and reduced-processing. High-processing strategies involve making an exhaustive search of the alternatives (e.g., different cars) and dimensions of those alternatives (e.g., size and color), as well as using arithmetic scales to make evaluations. Those strategies are involving similar approaches to the optimization techniques that we described earlier in this Chapter. An example of the use of a quantitative scale would be assigning values to dimensions and adding these values to get an overall score for each alternative. High-processing strategies are usually compensatory. In a compensatory strategy, a positive aspect of one dimension is permitted to compensate for a negative aspect of another dimension (Klayman, 1985). The decision-maker may not like one particular dimension of an alternative, for example, the rent on an apartment is a little high, but the high rent is compensated for by the fact that the apartment is in a better neighbourhood than others.

Non-compensatory strategies involve reduced-processing because these strategies allow the decision-maker to eliminate alternatives without doing an exhaustive search of all possible dimensions of those alternatives (Howse et.al., 2003). Non-compensatory strategies usually rely on heuristics (as described earlier in this Chapter) rather than optimisation processes. For example, alternatives may be eliminated on a pass or fail basis whereby an alternative is eliminated if it does not meet a critical value on one dimension. There are several different types of non-compensatory strategies. However, all types involve eliminating items that possess a weakness on at least one dimension that cannot be compensated for by strength on another dimension (Tversky, 1972).

Klayman (1985) pointed out that compensatory strategies are often used when decisions are simple, allowing the decision-maker plenty of time to explore all the alternatives and their associated dimensions. A choice between two apartments, for example, would generally allow the decision-maker to use a compensatory approach. On the other hand, sometimes when people are faced with a decision, they do not have time to examine all the possibilities before making a choice. When this is the case, they may use non-compensatory strategies, which allow the decision-maker to eliminate quickly certain alternatives if they are unacceptable on one or more dimensions (Howse et.al., 2003).
Payne, Bettman and Johnson (1993) suggested that non-compensatory strategies are easier to use than compensatory ones and as a consequence are used more often, especially when the decision-maker is faced with many alternatives and dimensions. Previous research has found that in complex situations, such as when adults are faced with choices that have six or more alternatives, they will generally use a non-compensatory strategy (e.g., eliminating all apartments with a high noise level) to help simplify the decision process (Payne et al. 1993).

2.3. Children’s Decision-making Literature

Although many research studies have examined how adults make decisions, relatively little work has explored decision-making in young children and how decision-making skills develop (Davidson and Hudson, 1988). Recently, however, researchers have begun to investigate the factors that affect children’s decision-making processes and how these change with age (Davidson, 1991a, 1991b; Davidson and Hudson, 1988; Klaczynski, Byrnes and Jacobs, 2001).

Several studies with younger children (aged 6-8) (Davidson, 1991a, 1991b; Klayman, 1985) have generally found that the strategies employed by younger children are different from those employed by older children (aged 10). Davidson (1991a) examined the decision-making strategies of 6, 8 and 10 years old children using a decision board, a method used previously with adults (Ford, Schmitt, Schectman, Hults, and Doherty, 1989). A decision board allows participants to open doors to examine information about different alternatives before making decisions. This procedure permitted the researcher to record what information was examined as well as the order in which the information was uncovered. Davidson (1991a, 1991b) found that compared with younger children, older children searched considerably fewer alternatives as well as fewer dimensions of those alternatives. Older children searched information more efficiently and systematically, and as a result, they made better decisions than did younger children.

Research on children’s decision-making (Davidson, 1991a, 1991b; Howse et al., 2003) has found that, unlike older children and adults, young children are frequently unable to eliminate an alternative as soon as it is obvious that it is unsuitable.

Davidson (1991a) argued that one possible reason that younger children’s decision strategies are not as proficient as those of older children in that they have difficulty distinguishing between relevant and irrelevant information. While this has not been studied extensively in the decision-making literature, researchers of cognitive psychology have found that younger children are more likely to attend to irrelevant information than are older children (Hagen and Hale, 1973).
For example Pick and Frankel (1973) argued that there is evidence that 10-year-old children are much better at focusing on relevant information in speed-limited classification tasks than are 8-year-olds. Similarly, younger and older children displayed differences in attention to relevant information on memory tasks (Miller, Haynes, DeMarie-Dreblow and Woody-Ramsey, 1986). In a selective recall task, Miller, Haynes, DeMarie-Dreblow and Woody-Ramsey (1986) asked 6, 8, and 10 year-olds to remember the location of items they had already seen behind closed doors. The 10-year-olds were more likely than younger children to open doors that contained relevant stimuli (items to be remembered). Younger children’s inability to differentiate between relevant and irrelevant stimuli interfered with their ability to perform well on this task (Miller et al., 1986).

Davidson (1991a) argued that in decision tasks, older children (e.g. 10-year-old), often eliminate alternatives when they see that they are unacceptable on a particular dimension (Davidson, 1991a; Klayman, 1985). Recognizing that an alternative is unacceptable involves attending to the relevant dimensions of that alternative. Davidson (1991a) suggested that once negative information is found for an item, the remaining information about that item becomes irrelevant. For example, if a bicycle is too small to ride, the colour is irrelevant, because small size makes it unacceptable as a choice. Older children are more likely to eliminate unsuitable alternatives than are younger children. They recognize that the size of the bicycle is relevant information and they attend to it and make their decisions based on that relevant information. However, younger children (6-8 years old) may not eliminate alternatives even when they are given information that the alternative is not suitable on a relevant dimension (Davidson, 1991a). They often continue to consider alternatives that should be readily eliminated when making decisions because they do not attend to the relevant information (e.g., in this case, the size of the bicycle).

Thompson (1994) pointed out that one possibility for why young children have difficulty eliminating alternatives is that they attend to more salient, but less relevant, information or cues. Although this possibility has not been examined in research on children’s decision-making, quite a few cognitive development researchers have addressed saliency as it guides children’s attention. Davidson (1995) argued that younger children do not recognize relevant information and they fail to use it in decision-making tasks.

Possible explanations for young children’s poor decision-making strategies have focused on the saliency of irrelevant information and a lack of motivation to ignore that irrelevant information (Davidson, 1995; Thompson, 1994). Davidson (1991b) suggested that whereas these may be possible reasons for younger children’s less proficient decision-making, another possible factor
may be a limitation in memory. Davidson (1991b) found that when 6-year-old children were given a visual aid to remind them which dimensions were important, these children searched the relevant dimensions more often and reported that these dimensions were more important. Indeed, young children often search unsystematically (Davidson, 1991a), shifting from one dimension to another on an information board.

Such unsystematic searching may be due in part to their not remembering which alternatives they have already ruled out. For example, a younger child might discover that a bicycle is too small and move on to examine information about a different bicycle, and later return to examine more information about the first bicycle, forgetting that it was eliminated earlier based on its size. Consequently, children’s decision-making difficulties may be affected by limitations in their ability to remember relevant information they discovered earlier in the decision process (Davidson, 1991a, 1991b).

Klaczynski, Byrnes and Jacobs (2001) argued that an additional explanation for why children may have difficulty ignoring irrelevant information is that they may not be motivated to do so. This lack of motivation could occur mainly for two reasons. Firstly, it takes effort to consider options carefully and ignore unimportant information, so it may not be worth the effort if one does not care about the decision. Secondly, it is possible that children may not realize that ignoring irrelevant information will lead them to make a better choice. Thus, they may be unmotivated to expend the resources to ignore irrelevant information when they do not realize that it will help them to make better decisions (Klaczynski et al., 2001).

The importance of motivation in design and technology education was identified by McCormick (2004). He argued that in design and technology classes, children have to be involved and learning has to be meaningful for them. If the activity is making a design decision, it should be a decision that matters and means something to the learner, in a way that will enhance children’s motivation about the design decision tasks.

2.4. Research from the Area of Psychology and Cognitive Development

Possible explanations of children’s behaviours when making a decision could be found in the area of cognitive development. The psychology of cognitive development studies the development of cognitive functions, processes, and abilities. That is, it examines the acquisition and transformation of those processes that enable humans to (i) understand the world in which
they live, (ii) cope with the problems that the world presents to them and (iii) store and organize their knowledge and experience about the world (Beilin, 1992, p.13).

The research of Piaget has contributed immeasurably to our understanding of the development of learning in children (Piaget, 1973; Piaget, 1972; Piaget, 1950). Piaget was a biologist with epistemological interests who set himself the task to advance a theory about the origin, nature, and adaptive functions of knowledge and intelligence (Beilin, 1992; Chapman, 1988). His life goal was to uncover and describe the underlying mechanisms that enable humans to understand the basic categories of reason, such as quality, quantity, causality, space, and time (Beilin, 1992).

2.4.1 Basic Elements of Piaget’s Theory

Piaget believed that reality is a dynamic system of continuous change, and as such could be defined with reference to the two conditions that define dynamic systems that change (Piaget, 1973). Specifically, he argued that reality involves transformations and states. Transformations refer to all manners of changes that a thing or person can undergo. States refer to the conditions or the appearances in which things or persons can be found between transformations (Chapman, 1988; Kitchener, 1986).

For example, there might be changes in shape or form (for instance, liquids are reshaped as they are transferred from one vessel to another, humans change in their characteristics as they grow older), in size, in placement, (e.g., a series of coins on a table might be placed close to each other or far apart) or location in space and time (e.g., various objects or persons might be found at one place at one time and at a different place at another time). Thus, Piaget (1972) argued that if human intelligence is to be adaptive, it must have functions to represent both the transformational and the static aspects of reality. He proposed that operative intelligence is responsible for the representation and manipulation of the dynamic or transformational aspects of reality and that figurative intelligence is responsible for the representation of the static aspects of reality (Piaget and Inhelder, 1973).

For Piaget (1973) operative intelligence is the active aspect of intelligence. It involves all actions, overt or covert, undertaken in order to follow, recover, or anticipate the transformations of the objects or persons of interest. Figurative intelligence is the more or less static aspect of
intelligence, involving all means of representation used to retain in the mind the states (i.e., successive forms, shapes, or locations) that intervene between transformations. That is, it involves perception, imitation, mental imagery, drawing, and language (Smith, 1996). Therefore, the figurative aspects of intelligence derive their meaning from the operative aspects of intelligence, because states cannot exist independently of the transformations that interconnect them. According to Vidal (1994) Piaget believed that the figurative or the representational aspects of intelligence are subservient to its operative and dynamic aspects, and therefore, that understanding essentially derives from the operative aspect of intelligence.

At any time, operative intelligence frames how the world is understood and it changes if understanding is not successful. Piaget believed that this process of understanding and change involves two basic functions: assimilation and accommodation (Kitchener, 1986; Vidal, 1994). Assimilation refers to the active transformation of information so as to be integrated into the mental schemes already available. Its analogy at the biological level might be the transformation of food by chewing and digestion to fit in with the structural and bio-chemical characteristics of the human body. Accommodation refers to the active transformation of these schemes so as to take into account the particularities of the objects, persons, or events the thinker is interacting with. For Piaget, neither of these functions can exist without the other (Chapman, 1988; Kitchener, 1986; Vidal, 1994). To assimilate an object into an existing mental scheme, one first needs to take into account or accommodate to the particularities of this object to a certain extent; for instance, to recognize (assimilate) an apple as an apple one needs first to focus (accommodate) on the contour of this object. To do this one needs to recognize roughly the size of the object (Kitchener, 1986).

### 2.4.1.1 The Stages of Operative Development

The following sections present an outline of the stages of cognitive development as conceived by Piaget (1973). Development is divided into two major periods on the basis of the kind of representation that dominates at each. Specifically, there is the period of sensorimotor intelligence, which lasts from birth to the end of the second year and the period of representational or symbolic intelligence, which appears thereafter and continues throughout life (Chapman, 1988; Piaget and Inhelder, 1973; Vidal, 1994). Representational intelligence is divided into two major periods. The first, which begins at age two and continues to about age seven, is preoperational, that is, it is representational but mental actions on representations are not yet coordinated into operative structures. For Piaget (1950), the foremost criterion of
operational coordination is reversibility, which involves understanding that a given action (actual or mental) can be cancelled or undone by another action. At the age of seven mental operations are integrated into reversible structures, thus preoperational intelligence is transformed into operational intelligence. Operational intelligence is concrete until approximately age 11-12 years when it becomes formal. Formal intelligence continues to develop until about the end of adolescence (Chapman, 1988; Kitchener, 1986; Piaget and Inhelder, 1973; Vidal, 1994).

- **Sensorimotor Stage (birth to 2 years)**
  A child comes into the world knowing almost nothing, but it has the potential that comes in the form of:
  - brain make up;
  - reflexes eg. sucking and visual orienting;
  - innate tendencies to adapt to environment.

Infants use these potentials to explore and gain an understanding about themselves and the environment. They have a lack of object permanence, which means they have little or no ability to conceive things as existing outside their immediate vicinity. For example, when you place a barrier, such as a piece of wood in front of an object an infant will believe that the object is non-existent.

- **Preoperational Stage (2 to 7 years)**
  Preoperational intelligence means the young child is capable of mental representations, but does not have a system for organising this thinking (intuitive rather than logical thought). The child is egocentric – which is they have problems distinguishing their own perceptions from the perceptions of others. A classic example is the phenomenon when a preoperational child will cover their eyes so they can’t see someone and think that that person can’t see them either. The child also has rigid thinking, which involves the following:
  - centration – a child will become completely fixed on one point, not allowing them to see the wider picture. For example, focusing only on the height of the container rather than both the height and width when determining what has the biggest volume;
  - state – a child can only concentrate on what something looks like at that time;
  - appearance – a child focuses on how something appears rather than reality;
  - lack of reversibility – a child cannot reverse the steps they have taken and does not realise that one set of steps can be cancelled by another set of steps;
• lack of conservation – realising that something can have the same properties even if it appears differently.

• **Concrete Operations (7 to 11 years)**
At this stage intelligence is now both symbolic and logical and acquired ‘operations’ represent a set of general rules and strategies. The most critical part of operations is realising ‘reversibility’ which means that both physical and mental processes can be reversed and cancelled out by others.

The concrete operational child will overcome the aspects of rigidity, apparent in a preoperational child, such as lack of reversibility, states, appearance and conservation. The tasks of concrete operations are:

- seriation – putting items (such as toys) in height order;
- classification – the difference between two similar items such as daisies and roses;
- conservation – realising something can have the same properties, even if it appears differently.

It is important to realise that operations and conservations do not develop at the same time. They develop gradually and are not an ‘all or nothing’ phenomenon. For example, the first to develop is number conservation followed by mass conservation, area conservation, liquid conservation and finally solid volume conservation. Thinking is not abstract. It is limited to concrete phenomena and the child’s own past experiences.

• **Formal Operations (11 to 16 years)**
During the stage of Formal Operations the child is capable of formulating hypotheses and then testing them against reality. Thinking is abstract, which means that a child/adolescent can formulate possible outcomes before beginning the problem. They are also capable of deductive reasoning.

**2.4.2 The Current Status of Piaget’s Theory**
There is a solid body of empirical evidence on most aspects of Piaget’s theory. Chapman (1988) argued that evidence enables us to draw certain conclusions regarding the validity of his theory, the permanent contributions that it has made to our understanding of the organization and development of human thought, and even about its potential further contributions.
The studies that evaluated Piaget’s theory can be classified into two broad categories (Chapman, 1988; Donaldson, 1978; Vidal, 1994). One group of studies was conducted to test the validity of the phenomena Piaget maintained he had discovered; for instance, is it true that children cannot solve the various conservation tasks before the age of seven? The second group of studies, which chronologically followed later, asked a deeper question: Is the theory itself right? This question is an important one because it reflects the difference between evidence and theory (Chapman, 1988; Kitchener, 1986; Vidal, 1994).

Researchers have replicated Piaget’s tasks in thousands of studies, covering the whole spectrum of ages, processes, and domains represented in Piaget’s studies (Brainerd, 1978; Dasen, 1977). They have tested the development of object constancy in infancy, the development of all kinds of concrete and formal operations, and also the development of various other processes such as egocentrism and memory. Vidal (1994) summarized this research and concluded that whenever a replication study remained close to the original Piagetian conditions, the same phenomena were observed in more or less the same way at more or less the same age. Thus, it is safe to conclude that Piaget was right in both the phenomena he discovered and their approximate age of occurrence (Brainerd, 1978; Dasen, 1977).

Some critics of Piaget theory argued that by describing tasks with confusing abstract terms and using overly difficult tasks, Piaget underestimated children’s abilities (Brainerd, 1978; Dasen, 1977). Researchers have found that young children can succeed on simpler forms of tasks requiring the same skills (Brainerd, 1978; Dasen, 1977; Vidal, 1994). Piaget’s theory predicted that thinking, within a particular stage, would be similar across tasks. In other words, preschool children should perform at the preoperational level in all cognitive tasks. Research has shown diversity in children’s thinking across cognitive tasks (Brainerd, 1978; Dasen, 1977). According to Piaget, efforts to teach children developmentally advanced concepts would be unsuccessful but researchers have found that in some instances, children often learn more advanced concepts with relatively brief instruction. Researchers now believe that children may be more competent than Piaget originally thought, especially in their practical knowledge (Brainerd, 1978; Dasen, 1977).

Donaldson (1978) challenged Piaget’s theory and tried to justify that Piaget may have undervalued child’s capabilities at various stages of development. Donaldson (1978) argued that Piaget’s stages of Operative Development follow one another in an invariant order: but, as
she put it, this is not because they are pre-programmed or wholly determined by maturation. It is because each stage builds on the one before it (p. 133).

Donaldson (1978) and Dunn (1988) argued that young children are not nearly as egocentric as Piaget supposed. For Piaget, this egocentrism (or 'subjective centring') was basic to the whole sweep of early development. For Piaget, children up to the age of seven or eight are, by virtue of their egocentrism, were largely incapable of taking into account other points of view, either logically or socially. Dunn (1988) illustrated that in suitable contexts very young children can and do show evidence of very considerable social and emotional sensitivity to others. Similarly, Donaldson (1978) arguing that children who would in Piaget's terms be classified as 'pre-operational' can be shown to be capable of quite subtle and sophisticated reasoning, provided that the testing situations make 'human sense'.

Whereas Piaget argued that competence for logical reasoning was only established in the early school years once the egocentrism of the young child was overcome, Donaldson (1978) argued that a considerable degree of intellectual competence is available much earlier. The reason that this early competence so often fails to show itself is that the child's thinking is still firmly embedded in (and thus dependent upon) the everyday contexts of social life.

Donaldson (1978, p.76) introduced the term “disembedded thought” which is equivalent to formal, abstract thinking. She also distinguished between disembedded tasks (abstract tasks not performed in realistic situations) and embedded tasks which are in everyday situations. Donaldson (1978) discussed research which proves that children do better on cognitive tasks if these tasks appear in a context that makes “human sense” to the child. She particularly emphasised the ability of a child to place a task in a socially meaningful context. If a situation is disembedded from a natural environment it will be more difficult to solve by children. The children will understand things much better if they are presented in a natural and familiar setting (Donaldson, 1978).

### 2.4.3 Vygotsky's Social Constructivism

Another important theory that explored children’s development was Lev Vygotsky’s studies, and more specifically Vygotsky’s Social Constructivism (Beilin, 1992; Luria, I976; Slavin, 2003; Wertsch, 1985). Vygotsky’s theory was built on the assumption that individual intellectual development cannot be understood without reference to the social environment in which the
child is embedded. According to Vygotsky (1971), all fundamental cognitive activities take shape in a matrix of social history and form the products of sociohistorical development. That is, cognitive skills and patterns of thinking are not primarily determined by innate factors, but are the products of the activities practised in the social institutions of the culture in which the individual grows up (Luria, 1976).

Vygotsky (1971) stressed the importance of society for child development. The child acquires certain concepts from the culture that surrounds them. Vygotsky believed that learning came from the outside, mainly through the use of language by older members of the community. Vygotsky (1971) emphasised that cognitive development occurs in situations where the child’s problem-solving is guided by an adult who structures and models the proper solution to the problem. Vygotsky (1978) described how cognitive functioning has its origins in the child’s social interactions. According to Vygotsky (1978) the “learning awakens a variety of internal development processes that are only able to operate when the child is interacting with people in his environment, and in co-operation with his peers” (p. 90).

To Vygotsky, a clear understanding of the interrelations between thought and language is necessary for the understanding of intellectual development (Beilin, 1992). According to Vygotsky language is not merely an expression of the knowledge the child has acquired. There is a fundamental correspondence between thought and speech in terms of one providing resource to the other; language becoming essential in forming thought and determining personality features (Wertsch, 1985).

2.4.3.1 Zone of Proximal Development

Zone of Proximal Development (ZPD) is the term introduced by Vygotsky to refer to “the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p.86). In other words, the actual developmental level refers to all the functions and activities that a child can perform independently. The zone of proximal development includes all the functions and activities that a child or a learner can perform with the assistance of someone else. The person in this ‘scaffolding’ process, providing non-intrusive intervention, could be an adult (parent, teacher, caretaker, language instructor) or another peer who has already mastered that particular function (Wertsch, 1985).
Scaffolding involves encouragement and assistance in the form of advice and suggestions to aid a child in mastering a new concept. Scaffolding is the final piece of Vygotsky's cognitive development theory (Wertsch, 1985). By using hints and pointers from teachers, parents, and peers who have already grasped the desired concept, children are able to form their own path towards a solution and by doing this eventually to self-regulate, or think and solve problems without the help of others (Slavin, 2003).

2.4.4 Bruner’s Theory

Bruner's ideas were strongly influenced by Vygotsky. He also supported that child development depended on social interaction. Bruner (1977) suggested that teachers should support children in performing certain activities. This may encourage children to take risks and may help them to feel more secure. Instruction should aid children in their thinking. Language acquisition depends largely upon participation in a dialogue carefully structured by the adult partner (Bruner, 1977).

According to Bruner (1977), children can perform a task when they are given instructions and assistance. The teacher is the supporter of child's learning development by providing a framework or "scaffolding". Bruner (1977) described scaffolding as a task given to children in a way that assures that only those parts of the task within the child's reach are left unresolved and knowing what elements of the solution the child will recognise though he or she cannot perform them.

Bruner was a strong proponent of education which dealt with the whole person. He thought that the main role of education is to help learners achieve excellence which can only be obtained through challenging learners with new tasks. Bruner (1977) stated that a good educator is "one who can diagnose the incipient intention of the child and act accordingly" (p.20). The learner should be encouraged to discover things for himself. He stressed the importance of learning how to learn which he understood as the ability to transfer the knowledge or skills from one situation to another.

Bruner (1977) argued that "learning should not only take us somewhere; it should allow us later to go further more easily." (p.17). Bruner gave the background for the "spiral curriculum" in which the teachers should introduce the basic topic and then revisit it cyclically in order to build on it and expand. A spiral arrangement of the subject matter allows an extension of each topic and a periodic revision of what has already been taught (Bruner, 1977, p.52). According to
Bruner (1977), grasping the structure of the subject matter is to understand it in a way that permits many other things to be related to it meaningfully. Bruner (1977) further explained that the act of learning involves three processes: acquisition of information, transformation - adjusting the knowledge to particular tasks - and evaluation - checking whether adjustment of knowledge is appropriate for the task (p.48).

Bruner offered his own stage theory; he divided development of an individual into three modes of representation. Representation is the way that we manage to keep hold of our past experiences in an orderly way. In the inactive mode learning takes place by manipulation of objects and things. In the iconic mode objects are represented by visual images. In the symbolic mode, symbols are used instead of objects or mental images (Bruner, 1966, p.11). Children need experiences which give opportunities for all three modes of the presentation (Bruner, 1977).

2.4.5 The Relationship of Piaget’s, Vygotsky’s and Bruner’s Theories

Piaget, Vygotsky and Bruner were all significant contributors to the cognitive development component of psychology (Woolfolk, 2004). Their ideas have also had considerable influence in education; the way children develop cognitively clearly plays a central role in their learning processes and abilities. By understanding the progression of cognitive development, teachers enable themselves to cater better to the unique needs of each child (Beilin, 1992).

Woolfolk (2004) concluded that Piaget, Vygotsky and Bruner were regarded as constructivists. Constructivism is an approach to teaching and learning based on the premise that cognition is the result of "mental construction". In other words, children learn by fitting new information together with what they already know. Constructivists believe that learning is affected by the context in which an idea is taught as well as by the children's beliefs and attitudes. Another similarity between Piaget, Vygotsky and Bruner is that they believe that the boundaries of cognitive growth were established by societal influences (Woolfolk, 2004).

Piaget believed that intelligence came from action. He held that children learn through interacting with their surroundings and that learning takes place after development. Vygotsky suggested that children’s learning is developed from their surroundings and from others. Piaget did not place importance on the input of others (Woolfolk, 1987).
The main difference between Piaget’s stages of cognitive development and Bruner’s stage theory is that although individuals pass through the modes of representation in a sequence during childhood, the adult uses these three (acquisition of information, transformation, adjusting the knowledge to particular tasks and evaluation, checking whether adjustment of knowledge is appropriate for the task) throughout life. Bruner also stressed that cognitive growth is influenced by culture and education. He emphasised the importance of language to the child’s thinking process.

2.4.6 Educational Implications of Piaget’s, Vygotsky’s and Bruner’s Theories

Beilin (1992) argued that methods and approaches to teaching have been influenced by the research of Piaget, Vygotsky and Bruner. All have contributed to the field of education by offering explanations for children’s cognitive learning styles and abilities (Woolfolk, 2004). While they may differ on how they view cognitive development in children, they offer educators good suggestions on how to teach certain material in a developmentally appropriate manner (Woolfolk, 2004).

Learning by discovery is supported both from Piaget, Vygotsky and Bruner and provides opportunities for learners to explore and experiment, thereby encouraging new understandings (Vidal, 1994). Opportunities that allow children of differing cognitive levels to work together often encourage less mature children to advance to a more mature understanding. One further implication for instruction is the use of concrete “hands on” experiences to help children learn (Brainerd, 1978; Dasen, 1977).

According to constructivist theory children learn by actively making sense of knowledge, by making meaning and by networking, connecting new knowledge to existing sets of ideas or schemes (Piaget, 1972). Recently, more account has been given by social constructivists to the social setting of learning and how interaction with others and the prevailing culture assists and influences learning (Von Glaserfeld, 1989). Traditional teaching approaches employ predominantly didactic methods of demonstration and explanation, whereas social constructivists (Vygotsky, 1986) would advocate more use of active involvement of the learner including genuine discussion, group work and collaboration (Cross, 2006).

Cross (2006) suggested that Vygotsky’s (1962) ideas, which emphasise language and interaction with others, are of considerable use to teachers of design and technology education.
Vygotsky (1962) commented that a teacher “working with the school child on a given question, explains, informs, inquires, corrects, and forces the child himself to explain” (p.34). This occurs within Vygotsky Zone of Proximal Development (ZPD), a transition area of capability where the pupil is able to achieve with the aid of a capable other en route to a state of independent capability. The ZPD appears to have meaning for learning in design and technology and consequently the teaching of the subject (Cross, 2006).

Vygotsky’s Zone of Proximal Development has many implications in education. One of them is the idea that human learning presupposes a specific social nature and is part of a process by which children grow into the intellectual life of those around them (Vygotsky, 1986). Conrad and Donaldson (2004) claimed that child to child interaction is key to Vygotsky’s belief that children learn from the viewpoints of others in order to build a more complex world view. Bruner’s principles such as scaffolding, co-constructed knowledge, dialogue, and cultural tools are all important components of a child’s knowledge acquisition (Woolfolk, 2004). Hamilton (2007) argued that there was evidence that teachers’ scaffolding provided an approach to learning that was significantly more productive in terms of their creative thinking, exploration and productive activity.

According to Hamilton (2007), sociocultural perspectives on learning place an important emphasis on the use of language in the construction of meaning. Hamilton (2007) supports Vygotsky’s (1986) theory that talk is central to learning, and understandings are developed through socially shared thinking within a collaborative context. Hamilton (2007) argued that “design and technology, with its emphasis on problem solving and goal oriented activity, has real potential for harnessing the creative energy and critical thinking skills of children’s through collaborative and contextualized activity” (p.34).

Other perspectives exist which draw on such ideas. A situated view of learning suggests that meaning does not come ready-made but has to be constructed through dialogue, interaction, and collaborative activity (Hamilton, 2007; Lave and Wenger, 1991). Hamilton (2007) pointed out that since learning is viewed as a reciprocal process embedded in the interaction between cognitive and social experience, the kinds of interactions that occur through action-oriented learning are personalized, goal-directed, and mutually supporting.

Fox-Turnbull and Snape (2011) suggested that in a constructivist approach, modelling and scaffolding are an integral approach to teaching and learning in design and technology.
Scaffolding is the process whereby teachers guide learners through activity in a manner that gradually increases the confidence and competence of the learners and can be applied in design and technology education (Hennessy, 1993).

Based on the literature reviewed, cognitive development could be considered as very important to the understanding of the learning and thinking methods used by children. Piaget, Vygotsky and Bruner offered some considerable insights into the possible ways children learn. By using these theories it is possible to create a more conducive learning environment for each child (Woolfolk, 2004).

2.5. Decision-Making in Education

In the field of educational research, decision-making strategies have only recently gained significant attention (Coles and Norman, 2005; Mettas and Norman 2008; Patronis, Potari and Spiliotopoulou, 1999). Most of the studies that explore the educational implementation of decision-making strategies are related with science education (Kennett and Stedwill, 1996; Kolstø, 2001; Patronis, Potari and Spiliotopoulou, 1999). There are few research studies that explored various aspects of decision-making in the area of design and technology education (Barlex, 2007a; Barlex, and Rutland, 2004; Coles and Norman, 2005; Davies, 2004; Mettas, 2011; Mettas and Norman, 2011; Mettas and Norman 2008; Mettas, Thorsteinsson and Norman, 2007).

Despite the importance of decision-making skills, a significant gap appears in literature on how actually children acquire decision-making in their classes. From the review of the existing literature it is obvious that only a limited number of scholars have examined the development of decision-making strategies, as part of children's education at schools (Mettas and Norman 2011; Mettas and Norman 2008; Patronis, et. al 1999).

Researchers exploring decision-making and the formation of moral judgments on science and technology based issues have reported a variety of factors that influence peoples' decisions (Carey and Smith, 1993; Driver et.al., 1996, Kuhn, Amsel, and O'Loughlin, 1989; Millar and Wynne, 1988). Zeidler and Schafer (1984) reported that positive attitudes and a strong commitment towards a particular issue were all positively related to the level of moral reasoning college students used to make social judgments. Fleming (1986a) found that adolescents primarily viewed science and technology based issues in ways that stressed their social
aspects. On the relatively rare occasions when adolescents used non-social cognition, their reasoning focused on their perceptions of scientists as finders and keepers of “true” facts (Fleming, 1986b).

2.6. Decision-Making in Design and Technology Education

The research on children’s decision-making capabilities in design and technology is very limited. Some studies that are available mainly described the importance of decision-making as a fundamental skill but do not explore what children actually do when they have to take a decision (Barlex 2007a; Barlex 2007b; Davies, 2004; Mettas and Norman 2011; Mettas and Norman 2008; Welch, Barlex and O’Donell, 2006). Davies (2004) argued that children’s design decisions play an important role in developing their understanding of the relationship between technology and society. Coles and Norman (2005) explored the effects of values in design and technology and suggested that values have an important role in design decision-making.

Mettas and Constantinou (2006) and Mettas and Constantinou (2008) explored the development of decision-making skills of pre-service teachers through a “Technology Fair” project. The pre-service teachers were asked to teach children aged 9-11 a specific decision-making technique, optimisation and present their outcomes to an event called “Technology Fair”. The results suggested that pre-service teachers improved their specific optimisation skills through instruction and teaching of children (Mettas and Constantinou, 2008).

According to Clemen (1991) decision-making refers to choosing between possible alternatives and this process is part of everyday activities. Middleton (2005) suggested that, in design and technology education, many activities provide decision-making opportunities that children have to acquire. Children are usually dealing with a range of decisions and facing different options, choices about construction materials and processes to use (Middleton, 2005).

In design and technology education children are usually dealing with “ill-defined” or “wicked problems” (Rittel and Webber 1973) and they “contain a complex of missing information, inexplicit requirements and conflicting demands” (Pedgley 1999, p.33). Greenwald (2000) characterized an ill-defined problem as being: “unclear and raises questions about what is known, what needs to be known, and how the answer can be found. Because the problem is unclear, there are many ways to solve it, and the solutions are influenced by one’s vantage
point and experience‖ (p. 28). Roberts (1992) argued as well about the nature of design problems and he stated that:

"Design problems are described as 'ill-defined' because there is no way of arriving at a provision description merely by the reduction, transformation or optimisation of the data in the requirement specification. By the same token, it is rarely possible to determine whether or not the finished design is 'the correct', 'the only' or 'a necessary' answer to the requirements. It must usually be possible, of course, to establish whether or not one 'proper' answer to the requirements is better or worse than some other proper answer” (Roberts, 1992, p.38).

An ill-defined problem can be introduced to children within the context of a larger, realistic scenario. In design and technology education, ill-defined problems become better defined and more contextualized as they are worked on and hence the solving and learning is through doing (Mettas and Consantinou, 2008). Throughout the design of a solution various decisions need to be made in order to end up with a proper and functional design. When the problem is “ill-defined” the decisions are usually more complicated because of the lack of specific information and constraints. As the problem transforms to “well-defined” the decisions are more specific and mathematical models could be used to improve the quality of the decision (Norman, 1998).

Although decision-making is an important issue for design and technology education, Kimbell, Stables, Wheeler, Wosniak and Kelly (1991) asserted that “in technology education programmes, little attention has been given to the discursive practices of justifying trade-offs, arguing for selection among other acceptable solutions, or persuading collaborators to contribute to a specific line of work” (Kimbell et al., 1991, p. 25).

Prime (1993) argued that very frequently technological decisions are not straightforward, i.e. there is no option that fulfils all the requirements better than others. A short quote from his argument stated that:

“Technology often poses real ethical dilemmas in which there are no obvious right answers or altogether satisfactory solutions. In such cases the challenge is to weigh all relevant contextual factors and to be guided by the values deemed to be more important in that situation.” (p. 32).
Designers also make choices when planning to make artefacts created for specific purposes. As Layton (1993) put it, "[t]here is nothing inevitable about the form which technology takes; it is shaped by the value decisions of those in control" (p. 47). A knowledge-of-practice perspective acknowledges that the values of a community come into play when selection of a solution is made, and affords a critical dimension to a technological stance.

Layton (1993) argued that value judgements are central in all the steps of the design process because they influence greatly the outcome and the degree of the designer satisfaction with the final design. Layton (1993) identified the important role that judgement plays in designing:

"Judgements about what is worthwhile and feasible initiate the activity. Judgements about the appropriateness of the design, and the means of realising it, shape the activity; and judgements about the functionality and effects of the product determine which steps are next required. The range of values is extensive, including technical, economic, aesthetic, social, environmental, moral, and design and technology activity is unavoidably concerned with the identification and reconciliation of conflicting value". (Layton, 1993, p. 21)

In design and technology, decisions are required almost at every step of designing (Davies, 2004). According to Middleton (2005), such decisions relate to the kind of materials and processes to use, the kind of artefact they produce, whether their proposed solution involves hazardous processes, or will have features that might be dangerous for the user of the product.

Barlex and Rutland (2003), argued about the need to investigate the pedagogy that enables teachers to engage children with using appropriate knowledge and skill to make design decisions relevant to food technology. According to Barlex and Rutland (2004) an important step is to audit a variety of design decisions that are likely to be made by children tackling a design and make activity. Additionally to Middleton (2005) ideas about the types of decisions in design and technology, Barlex (2005) described five groups of design decision-making as follows:

- Conceptual decisions, are concerned with the overall purpose of the design, that is, what sort of product it will be.
- Marketing decisions, are concerned with, for example, who the design is for, where will it be used and where will it be sold.
- Technical decisions, are concerned with how the design will work.
Aesthetic decisions, are concerned with what the design will look like.

Constructional decisions are concerned with how the design will be put together.

Barlex (2005) model can be represented visually, as shown in Figure 2.1, with each type of decision at a corner of a pentagon and each corner connected to every other corner.

![Design Decisions Pentagon](image)

**Figure 2.1 - The design decisions pentagon (Barlex, 2005)**

Barlex (2007a) argued that in the above model a change of decision within one area will affect some, if not all of the other design decisions. For example, a change in the way a design is to work will almost certainly affect what the design looks like and how it is constructed. Barlex (2007a) went further and claimed that the model can be used as a formative or summative tool to encourage pupils to track and evaluate their design decisions at relevant points during a designing and making activity. The model encourages ‘pupils to focus deliberately, but not exclusively, on particular features of his or her designing without losing the important holistic overview of the design process’ (Barlex, 2007a).

Rutland (2009) suggested that the model of Barlex has proved to be a useful tool and framework for supporting sound decision-making when design and making is refined and used by pupils in all the focus areas of design and technology, including food technology, resistant materials, systems and control and textiles technology, to evaluate, refine and develop their design decisions and foster their creativity when designing and making’ (Rutland 2009, p.63).
Trebell (2011), explored pupils’ beliefs about designers and designing and she analysed the responses about what the designer needs to know in order to design a product according to categories drawn from the design decisions pentagon developed by Barlex (2005). From Trebell’s (2011) results, Barlex’s (2005) pentagon was developed further by adding two new categories, the first dealing with materials, that is, what materials will be used? The second dealt with safety issues, that is, will the product be safe to use? Trebell’s (2011) model of design decisions is represented visually, as shown in Figure 2.2 with each type of decision at a corner of a heptagon and each corner connected to every other corner.

![Design decision heptagon](image)

**Figure 2.2- Design decision heptagon (Trebell, 2011, p.29)**

Welch and Barlex (2009) observed elementary school children while designing, through the use of exploratory talk (talking aloud) and they concluded that “the idea of pupils being able to make better design decisions through the use of exploratory talk is tantalising and worthy of further consideration” (p.108). Additionally, Welch and Barlex (2009) found out that most of the design decisions made by the pupils were concerned with aesthetics and construction, although there was a brief discussion concerning the technical issue of achieving balance.

Nicholl and McLellan (2007a and 2007b) presented the idea that lack of creativity in children’s design and technology projects is at least partly the result of fixation. They defined fixation as
the “difficulty in generating novel ideas due to imagination being ‘structured’ by pre-existing knowledge” (p.71). Such lack of creativity could also affect children’s decision-making in developing alternative options.

Nicholl and McLellan (2007a) argued that the stereotypical design ideas based on popular culture typically seen in secondary D&T classrooms in the UK are the outcome of fixated thinking. Because imagination is structured and operates along the path-of-least resistance, children will draw on sources of knowledge that are most accessible to them. As Nicholl and McLellan (2007a) stated “common shapes and images such as love hearts and footballs form the basis for design ideas. Hence, stereotypical design ideas are the outcome of the operation of subconscious, automatic and normative cognitive processes that have lead to fixation” (p.72).

Additionally Nicholl and McLellan (2007a) argued that the provision of examples from previous projects appears to reinforce default cognitive processes that are unlikely to result in creative decision-making. Jansson and Smith (1991) argued that providing examples can be detrimental to design work, as features that have been pointed out as exhibiting poor design may actually be integrated into designs subconsciously. If children are not given guidance in how to conduct a product analysis (for instance in terms of what images to source) or in how to use this in generating design ideas, in the absence of any other input again, creative thinking will default down the path-of-least-resistance with the likelihood of producing fixated outcomes (Nicholl and McLellan, 2007b).

Neisser (1976) claimed that children tended to direct attention to what teachers said. Similarly Nicholl and McLellan (2007b) pointed out that teachers who gave attention to existing products were guiding children’s design decisions and as a result their eventual designs. The influence of teachers’ ideas on children’s design and technology projects was also identified from McCormick (2004) as well. Teachers were considered to be an important source of information for children’s design work (McCormick, 2004).

Black (2008) pointed out that school subjects should be taught in such a way that pupils’ autonomy is developed. Design and technology offers many opportunities for such development, as pupils are required to make their own decisions about their designs and subsequent products. Rutland and Barlex (2006) observed food technology teacher trainees, while teaching in class and they found that there was a range of decision-making opportunities given to children. Rutland and Barlex (2006) concluded that sometimes pupils during their
projects were making no design decisions; they were mainly focusing on practical skills and in some cases pupils were following more open investigations with more design decisions taken by them. For example “the pupils were ‘investigating burgers’ with a focus on ‘health’ and evaluating them for quality including cost, nutrition and target market. They worked in groups, drew up a sensory analysis chart and evaluated the burgers against shape, size and method of cooking” (p.6).

Mettas, Thorsteinsson and Norman (2007) concluded from a study of three national curricula (Cyprus, England and Iceland) that although there are many opportunities for decision making in design and technology classes in practice some teachers believe this is not feasible. The teachers suggested that children rarely ‘set appropriate criteria to support their design decisions’ and that associated formal training in decision making techniques might ‘improve the quality of children’s decisions during design activities’ (p.68).

Decision-making is an important issue in design and technology education and involves many factors. Davies (2004) suggested that a vital characteristic of a design and technology teacher is the ability to empower children to make their own design decisions. A decision can be taken at various steps of designing; either while evaluating the range of solutions or while deciding on the appropriate materials to be used (Davies, 2004). It is also important that children, when making their decisions, are aware of different factors that influence the product design and those factors usually are related to knowledge, values and skills (Hicks, et al., 1982).

### 2.7. Knowledge Skills and Values in Design Decisions-Making

Hicks et al. (1982) categorised the most important influences for design and technological activity as knowledge, skills and values. The knowledge, skills and values model has also been adopted by other researchers such as Pedgley (1999) and Trimingham (2008). Norman (1998) suggested that effective design is ‘bounded’ by the designers’ knowledge, skills and values, and that education or professional development should seek to address these as key issues. In the school environment knowledge, skills and values are also likely to have an influence on children’s designing activities in design and technology education. Norman (2000) presented a model of designing based on knowledge, skills and values (Figure 2.3).
The involvement of knowledge, skills and values in decision-making has also been acknowledged by many other researchers (Aikenhead, 1994; Aikenhead, 1989; Coles and Norman, 2005; Mettas and Norman, 2008; Trimingham, 2008). Values are a core element of effective decision-making because they describe our objectives: what we as decision-makers want to accomplish. The use of appropriate knowledge is also important because it formulates the theoretical background needed in order to make comparisons between different features of available choices. Skills are required as well, when values and knowledge need to be combined together in order to work out the different processes and strategies that could be used (Baron and Brawn, 1991).

Hicks et al. (1982) suggested that in design and technology education the combination of knowledge, skills, and values in various design tasks allows pupils to maximize their problem solving and decision-making skills, their flexibility and adaptability to other aspects of life as well. Hicks et al. (1982) pointed out the importance of knowledge, skills and values in the domain of design and technology in general and in design decision-making in particular:

“It is when the three components of this framework (skills, knowledge and values) come together in one activity that it can be termed ‘technological’. However, whereas all types of
design activity share the three components it is when the knowledge component is analysed in detail that the activity assumes a greater or lesser technological significance” (p.7)

By the same token Norman (1998) explored the relationship between knowledge, skills and values in design activities and indicates how one factor influences the existence of other factors:

“Individual designers operate within a particular design area and it is possible, from the design activities in that area and its products, to identify knowledge, skills and values which it might prove helpful for the individual designer to acquire. This is not a causal relationship i.e. the acquisition of these knowledge, skills and values will not guarantee the designer success; neither is it an exact relationship i.e. there is no guarantee that for a particular project the designer might not need to acquire further knowledge, skills or values. Knowledge, skills and values so identified represent common elements associated with the range of activities and products studied. It is not an irreducible minimum in the sense that each element occurs in each activity and product – they are likely to be more disparate than that. They are elements that are associated reasonably frequently with activities or products in a particular area of the design field.” (Norman, 1998, p.76)

Therefore, a crucial issue in design and technology education should be the degree of skills, knowledge and values that are involved in design and technology education in general and in design decision-making in particular. The exploration of those crucial issues and their contribution in decision-making could lead to new ideas about effective teaching of decision-making skills.

2.7.1 The Role of Values in Design Decision-Making

The importance of exploring values in design and technology education has been argued by a number of authors as a vital characteristic of a comprehensive technology curriculum (Barlex 1993; Breckon 1998; Holdsworth and Conway 1999; Keeney, 1992; Layton 1991; McLaren 1997; Prime 1993). Despite the obvious significance of values in decision-making, only in recent years has research explored their in-depth involvement in decision-making (Coles and Norman, 2005; Trimmingham, 2008).
Keeney (1992) argued that people make decisions because of their values and not because alternatives are thrown in their path. A key to good decision-making is to express these values clearly, to create a set of alternatives that address those values, and finally to choose the best one (Keeney, 1992).

From the early stages of introducing and developing design and technology education as a learning area throughout the world, values have been recognized as an important element of curriculum (Pavlova, 2005a). Gregory, Gaultney, and Tish (1994) argued that some of our values relate to social objectives while other values are clearly very personal or idiosyncratic. Within any group of people, differences in values can lead to differences in choices or differences in the assessment of alternatives.

In design and technology, children have the opportunity to explore the different choices available to them and to discuss their values and beliefs. Children understand the difference between fact, opinion, and values; and develop an ability to make rational decisions, while recognizing the role of subjective interpretation (Pavlova, 2005a). Children need to analyse choices and consequences. Sometimes, there are only difficult choices or bad choices; but in the end, one choice is better than the others (Prime 1993).

An important argument supporting the significance of values in technology education relates to the provision of a basis for “value-based decision in the designing, implementing and evaluating of technology, in situations that are ethically complex” (Prime 1993, p. 34). Value judgements are considered as “the individual decisions or choices which make the values of people explicit” (Holdsworth and Conway 1999, p. 206) and which are closely connected to personal integrity and personal identity. Values provide a basis for choice, decision-making and action in a wider context (Pavlova, 2005a).

Holdsworth and Conway (1999) pointed out that it is possible that teachers put the highest priority on teaching technical values. Their hierarchy of values appeared to be the following: technical, aesthetical, economic, environmental, social, cultural, moral, and political.

According to Middleton (2005) values in design and technology are components of the design problem space and values apply to designing at both the professional and school level. Values, as a component of professional design, may be implicit and based on the professional designers’ expertise. In design and technology education, where knowledge about values is as
important as the fact of their incorporation in learning to design, values need to be an explicit aspect of designing.

Prime (1993) argued that technology “often poses real ethical dilemmas in which there are no obvious right answers or altogether satisfactory solutions. In such cases the challenge is to weight all relevant contextual factors and to be guided by the values deemed to be more important in that situation” (Prime, 1993, p. 32). Thus the relative nature of all decisions is acknowledged, and no general guidelines for decision-making are given to teachers or to children (Pavlova, 2005a).

Conway (1994) suggested that there is a sense in which technology, both its products and its processes, represents the embodiment of the culture. According to Conway (1994) we create the things we value, the things we think beautiful or useful. We devise tools, machines and systems to accomplish the ends we value. Our beliefs, our values, our philosophies, our experiences, in short our culture, is made manifest, in part in the artefacts and systems we create.

Layton (1993) characterised the role of values in technology education as the ‘the ability to judge the worth of a technological development in the light of personal values and to step outside the 'mental set' to evaluate what it is doing to us (e.g. it might be encouraging a view of social problems in terms of a succession of 'technical fixes' rather than more fundamental considerations)’ (p. 61).

McLaren (1997) discussed the teachers’ responsibilities about the various values that should be developed in technology classes. ‘Teachers have a responsibility to raise awareness and increase understanding of social, ethical, environmental, economic values and issues involved in design in order that pupils can attempt to make informed, considered and sensitive value judgements’ (McLaren, 1997, p. 259).

Hicks et al. (1982) identified four crucial areas in which it is possible for values to be assessed in the area of design and technology. Those values could affect design decision-making and according to Hicks et al. can be grouped in four categories:

1. Technical values (e.g., efficiency, flexibility, precision and confidence);
2. Economic values (e.g., value, price and cost);
3. Aesthetic values (e.g., self-expression, workmanship and proportion);
4. Moral values (e.g., impact on the environment, religion and needs, social) (1982, pp.6–7).

Trimingham (2008) investigated the role of values in design decision-making. She reviewed the existing literature (e.g., Coles and Norman, 2005; Hicks et al., 1982; Layton, 1992) and categorised the types of values that are involved in design decision-making. Subsequently, she investigated those values and developed categories for a taxonomy of the values influencing design decision-making. She summarised the values in the following categories:

- Societal values (e.g. gaining information from members of society about for instance their preferences, priorities, convictions and emotions)
- Identified stakeholder values (e.g. paying attention to a brief that has been written by an identified stakeholder)
- Economic values (e.g. an understanding of the importance of minimising cost and of knowing the cost of materials, processes, and designer time)
- Values embedded in design (e.g. the use of existing design as a source of inspiration and/or to inform decisions; the use of existing design as a start point for new designs)
- Perceived societal values (e.g. the perception of for instance the preferences, priorities, convictions and emotions of society)
- Perceived identified stakeholder values (e.g. the perception of for instance the preferences, priorities, convictions and emotions of identified stakeholders)
- Perceived economic system values (e.g. a perception of the cost of materials, processes, and designer time);
- Embedding values in design (e.g. the use of existing designs as a start point for new designs in order to embed their value in the new design)
- Designer’s personal values (e.g. the designer personal preferences, conviction, priorities and emotions)
- Meta-values (e.g. making judgements in order to guide the activity and decide what steps to take next) (Trimingham, 2008, pp. 47-49)

Trimingham (2008) argued that the use of values in design decision-making needs to be included in course curricula and presented within a framework of knowledge, skills and values. She went on and pointed out that: “It is clear that values influence design decision-making in many ways, for instance they are used to reduce avenues of enquiry, to direct activity, to
analyse ideas, to inform about sizes, properties, functions and manufacture, among many other areas. Values are used to drive all sorts of decisions from manufacturing to aesthetics and yet their comprehension by designers is currently made at a personal cognitive level‖ (p.50)

Trimingham (2008) pointed out that for some design projects the values influencing the designers’ decisions may be straightforward to identify, but in other cases constituent factors leading to decisions might be complex in their structure and relationships. Trimingham (2008) stated that: ―by furthering our understanding of design decision-making it is possible to develop more effective teaching practices and resources. This enables children to improve their design capability and essentially become better designers.” (p.50).

2.7.2 The Role of Knowledge and Information in Design Decision-Making

Reasoned choices and evaluation are often based on values but, although values are an important basis for making a judgment, the use of relevant conceptual knowledge is needed in order to weigh the advantages and disadvantages of the available options (Perkins and Salomon, 1989; Sadler, 2004). Piaget (1972) theorized that individuals tend to reason at more sophisticated levels in areas in which they have more knowledge. If the nature of designing is related to decision-making on technological issues, as is commonly assumed, then from Piaget’s theory it follows that those who understand the nature of technology should reason differently on those issues than those who do not.

According to Kimbell (2005), the role of knowledge in design and technology has always been tricky. Polanyi (1962) described the way that people handle various ideas and information around them utilising their ability to operate with ‘tacit’ knowledge. Which is to say (e.g.) that the way builders choose cross sections of material was not based on explicit, formally constructed mathematics, but by operating on their tacit understanding of what works.

Sadler (2004) concluded that given the fact that technological issues often involve ideas from the frontiers of research, most people must rely on outside sources of information to form positions regarding these issues. He went on and suggested that information of this type is transmitted to decision-makers through a variety of sources including newspapers, magazines, the Internet, politicians, teachers, friends, and family. Research on how people evaluate information pertaining to technological issues suggested that most individuals are ill-prepared for the task (Perkins et al., 1991; Sadler, 2004).
Clemen (1991) argued that in order to improve knowledge information is required and as a result to make good decisions. Not all information, though, is of the same quality or relevance for the decision that needs to be made. Clemen (1991) pointed out that this is an important matter, because many curricula, asking children to make decisions, assume an innate capability to distinguish between useful and irrelevant, or even incorrect, data.

Sadler et al. (2004) suggested that information evaluation needs to be a strong component of scientific and technological issues curricula and instruction. Some studies argued that many children require direct instruction in how to use strategies for evaluating scientific reports as well as experiences in discriminating between scientific evidence and other forms of information (Kolstø, 2001b; Korpan et al., 1997; Perkins and Salomon, 1989; Tytler et al., 2001).

Jimenez-Aleixandre and Pereiro-Munoz (2002) suggested that when dealing with problem solving, in order to make a decision, it is important to identify which knowledge is relevant for the problem, and which sources are reliable. The next step would be a synthesis of the different areas or fields of knowledge that are considered both relevant and reliable. Ratcliffe (1996) explored the development of information processing and analysis as one important strand in decision-making, showing the difficulties in increasing the use of an information base and calling for a careful assessment of children’s abilities before grouping them.

Kolstø (2001a) performed a qualitative study to detect the manner in which children evaluate information and knowledge in socio-scientific decision-making. From his findings, the children based their judgments on two factors: the informational statements themselves or the authorities who provided the information. Children accepted or evaluated the information, or they accepted or evaluated the source of information (Kolstø, 2001a).

Several teaching models for thoughtful decision-making for use in education have been proposed (Aikenhead, 1985; Geddis, 1991; Kolstø, 2000; Ratcliffe, 1996). Ideally such teaching models should build on knowledge of the strengths and weaknesses in children’s decision-making. However, only a few studies have explored the kinds of knowledge children draw upon, and how they actually apply this knowledge, when confronted with technologically controversial social issues (i.e. Fleming, 1986a, 1986b; Ratcliffe, 1996).
Gilbert (1991) pointed out that when children face decision-making problems they usually solve the problem by empirical knowledge, which exists apart from scientific knowledge and this sometimes does not produce the best consequences.

Venville, et al. (2004) investigated the sources of information that children employ while working with design activities. The trials performed during class were frequently used as a source of knowledge by children and gave them critical information to make decisions about their designs. Designs that children had used in previous years were used as an important source of knowledge by some of these children. This process of networking, using other children and people outside the class as sources of information, is similar to Roth (1998) descriptions of learning communities. The teacher was a respected source of information and was well used by children at one time or another in the design project.

The importance of knowledge and understanding in design and technology education had been identified as an area of concern by a number of authors (De Vries and Tamir, 1997; Herschbach, 1995; Pavlova, 2005a). De Vries and Tamir (1997) argued that “the epistemology of technology is by no means yet a fully developed area” (p. 7). Herschbach (1995) also stated that: “it makes little sense to talk about curricular strategies until the epistemological dimensions of technological knowledge are first determined.” (p. 32).

From the introduction of design and technology education many researchers have attempted to identify an official and formal body of knowledge for particular areas of design (Norman, 1998). This knowledge aims to develop technological literacy, i.e. what a child needs to be familiar with for the practice of technology. An important part of the definition of this knowledge belongs to the application of concepts and skills in order to solve certain types of technological problems. According to Kimbell (1994) the term ‘capability’ was introduced to capture the practical, conceptual and procedural dimensions of technological knowledge (Kimbell et al., 1996).

Vincenti (1984) divided technological knowledge into three types: (a) descriptive, (b) prescriptive, and (c) tacit. The first two types are varieties of explicit technological knowledge. Tacit knowledge is implicit in the activity of the person, and it is the outcome of an individual’s judgement, skill and practice (Polanyi 1962). Tacit knowledge cannot be easily expressed formally. It is personal knowledge; it is subjective knowledge. It is transmitted mainly from one individual to another.
Herschbach (1995) argued about the development of tacit knowledge: “tacit knowledge is primarily learned by working side by side with an experienced technician or craftsman. Tacit knowledge is embedded in technological activity to a greater extent than is normally recognized. In addition, tacit knowledge has not disappeared with the use of more sophisticated ways of manufacturing based on the application of science and descriptive technical knowledge” (Herschbach, 1995, p. 36). Polanyi (1967) suggested that all human action involves some form of tacit knowledge.

Herschbach (1995) claimed that descriptive knowledge “represents statements of fact which provide the framework within which the informed person works, such as material properties, technical information, and tool characteristics. These facts are often applications of scientific knowledge” (p. 34). He further argued that descriptive knowledge approaches an approximation of the formal knowledge of a “discipline” since it describes things as they are. It can be in the form of rules, abstract concepts and general principles, and it often has a consistent and generalizable structure. Like all technological knowledge, however, descriptive knowledge finds its meaning in human activity.

McCormick (2004) attempted to define the nature of technological knowledge with an emphasis on two basic types of technological knowledge: procedural and conceptual.

- **Procedural knowledge** includes such things as: design, problem solving, planning, systems analysis (or systems approach), optimisation, modelling, strategic thinking (heuristics, algorithms and metacognition).
- **Conceptual knowledge**: for example, systems concepts (McCormick, 2004).

When designing, designers and children apply knowledge from a wide range of areas. The exact form of knowledge needed by designers is currently under debate. Hicks et al. (1982) stated that designers often require information from other disciplines when making decisions. According to Norman (1998), the information used by designers could be obtained from various sources but only when information is processed in designers’ minds does it become knowledge.

Technological knowledge could be considered as a component of technology relevant to a particular design area (Norman, 1998). The relation of technological knowledge with scientific knowledge has been identified by many researchers (Hicks et al., 1982; Layton, 1993). Some of them identified technology as being applied science and therefore scientific knowledge being
very important in technology. Hicks et al. (1982) made a connection of technological knowledge with knowledge from other disciplines.

“Designers are continually called upon to make decisions which require information from other disciplines. The form in which this information is needed means that the questions may differ in kind from questions which would arise from a study of those disciplines themselves. For example, although scientific information may be needed when designing, the form in which it is needed requires the generation of new concepts – i.e. technological concepts” (Hicks et al., 1982, p 5).

Norman (1998) argued that the above statement about the reformulation of knowledge for practical action could sometimes be misleading, because practical actions can be guided by both tacit knowledge and conceptual knowledge. Norman (1998) pointed out that design decisions are developed through cognitive modelling, and hence the use of tacit knowledge can be considered likely. According to Archer and Roberts (1979), “the existence in man of a distinctive capacity of mind is analogous with the language capacity and the mathematical capacity” (p. 55), and this adds to the complexity of understanding design decision-making.

Within the literature there are differing interpretations about the nature of technological knowledge. This causes difficulties in defining technological concepts to be introduced to children. Technology relies on multiple knowledge bases but these can neither be identified nor can technology be reduced to them (Salomon, 1995). A restricted view of technological knowledge limits children’s learning in technology by considering only some aspects. According to Perkins and Salomon (1989), it is important that a more coherent picture of technological knowledge is developed. The translation and transfer of knowledge and skills is required in technological practice. Teaching for transfer is difficult but there is some evidence that it is possible (Perkins and Salomon, 1989).

De Vries (2003) explained how many categories of technological knowledge have a normative nature. Hence they are, for example; effective, or ineffective; good, or bad. Pavlova (2005a) argued that knowledge is relative, based on a person’s experience and directed by human needs and wants and as a result, the use of such knowledge needs the existence of values. She went on and claimed that is not sufficient to develop a coherent analysis of technological knowledge as it cannot be free from interests, desires and values (Pavlova, 2005a).
2.7.3. The Role of Skills in Design Decision-Making

Skills have an important role in decision-making (McCormick, 2004; Newmann, 1990). In such a dynamic society, the teaching of thinking skills turns out to be essential (Newmann, 1990). However, little attention has been given to teaching children the very important and daily used skill of decision-making and as a result this issue is largely unexplored. Good decision-making involves the integration of personal and social values with sources of information and knowledge. In order to integrate values and knowledge, thinking skills should be applied.

Dasgupta (1996) introduced the concept of ‘bounded rationality’ (p.43) a term that Bazerman (2005) also used to explain the obstacles of using available information and knowledge. Dasgupta (1996) explained that a designer’s knowledge may be erroneous, they may not possess the requisite knowledge to lead to a desired goal, or knowledge may be incomplete (i.e., deciding whether or not to take an umbrella) (pp.43-44). Lawson (2004) argued that this personal use of knowledge suggests that there is ‘some higher quality depending on some identifiable body of knowledge lying outside and beyond the problem’ (p.10).

In design and technology education, skills are fundamental almost in every step of designing. According to Baynes (2009), “Design activity is the exercise of the set of skills useful in planning, making and evaluating.” (p.45). In some instances the designer may not be able to use the information in its original form and may need to deconstruct and restructure it as necessary (Layton, 1993, Figure 2.4) because ‘…in order to be used effectively it must be transferred into designerly knowledge’ (Cross, 1982). This is important in our understanding of skill, as Layton suggested this restructuring occurs for practical action.

Figure 2. 4 - Restructuring of designerly knowledge (Layton 1993)
Daley (1982) supported this ‘personalised’ way in which designers use propositional knowledge and he states: “...the mind may not have a systematic way of knowing or conceiving the schemata of which can be definitely described” or designers may use visual rather than verbal representations of information. The term ‘schemata’ refers to organised networks of knowledge. It is considered as a dynamic entity, where the strength of links between networks varies and changes. This network of organised schema is also attributed to our ability to perform certain skills, such as face recognition (Daley, 1982), or the tacit knowledge of procedure (Schön 1983).

Archer (1992), attempted to clarify the meaning of the term cognition and its use in design and technology. Archer stated:

“cognition’ is intended to embrace all those processes of perception, attention, interpretation, pattern recognition, analysis, memory, understanding and inventiveness that go to make up human consciousness and intelligence” (Archer 1992, p.5).

As suggested by Newmann (1990), a higher-order thinking skill “challenges the child to interpret, analyse, or manipulate information, because a question to be answered or a problem to be solved cannot be resolved through the routine application of previously learned knowledge” (p.44). Solving problems and analyzing information requires the skill to make choices between competing strategies and decisions among alternative approaches. Although evidence of higher-order thinking is therefore obtained if a child achieves these goals, the actual process to be followed is not set out (Newmann, 1990).

Polanyi (1962) in his attempt to describe the notion of skills argued that “...you cannot acquire a skill merely by learning to perform its fragments, but must also discover the ability of coordinating them effectively”. Additionally Hicks et al. (1982) argued that skills play an important role in almost every design and technology activity. Hicks et al. (1982, p.6) identified four core categories in design and technology in which skills could be developed: investigation, invention, implementation, and evaluation, or validation (1982, pp. 4–5). All these categories are essential elements of design and technology education and could enhance decision-making skills. They are described as follows:

**Investigation**- includes the ability to recognise the existence of a problem which might be amenable to solution though design and technology activity; the ability to perceive, or identify through investigation, how far a given thing or system meets the stated need; the ability to look for information and resources and generate information through observation
and resources obtained; and the ability to employ a balance of knowledge, analytical skills and judgement in reaching conclusions in the face of ill-defined problems.

**Invention** – Includes the ability to initiate and develop ideas and images of proposed things or systems, and to manipulate, rotate and transform those images; the ability to think of alternative configurations for a desired thing or system and to adapt, transform and select from these to meet given needs; the ability to express these images in various ways, such as sketching, drawing, diagram making, constructing, or through the use of notation or language, and thus to communicate information about them to others; and finally the ability to examine the integrity and coherence of a product or system, how well it matches its requirements and how well the requirements themselves are appropriately defined.

**Implementation**- includes the ability to plan a practical activity and to see it through; the ability to select from available resources the most appropriate means for gaining the desired effects; the ability to use tools, instruments, materials, components, appliances and appropriate energy resources; and the ability to monitor and measure the effects of operations and to control their outcome.

**Evaluation**- includes the ability to discern the context within which the designed product or system is to be considered, and to identify the related criteria by which it should be judged; the ability to choose the measures appropriate to given criteria and to devise practical or logical tests to determine the performance of a given product or system in relation to them; the ability to form judgements about the balance or merit of a given thing or system in respect to given criteria; the ability to distinguish between needs of different sorts and to assign different degrees of importance or priority to given needs in different circumstances; and the ability to appraise the efficacy of a given design activity. (Hicks et al., 1982 pp. 4-5)

**2.8. The Influence of Society in Design Decision-Making**

Aikenhead (1985) argued that decision-making skills can help children activate their thinking and problem-solving abilities by developing a better understanding of the impact of their choices on themselves as well as friends, neighbours, the community, or society as a whole. Hence decision-making could help children to become active members of the society that they live in, but at the same time society will affect children’s decisions in class.
Rational decision-making is a core element in modern societies when “socioscientific issues” are under consideration. The phrase “socioscientific issues” has come to represent a variety of social dilemmas with conceptual, procedural, or technological associations with science (Fleming, 1986a; Kolstø, 2001a; Patronis, Potari, and Spiliotopoulou, 1999; Zeidler, Walker, Acket, and Simmons, 2002). Socioscientific or sociotechnological issues typically involve the products or the processes of science and technology and create social debate or controversy (Sadler, 2005).

All societies have issues that can be deemed controversial. Controversial means that significant numbers of people argue about them without reaching a conclusion (Oulton et al., 2004). This can be the case, for example, where insufficient evidence is held in order to decide the controversy, or, where the outcomes depend on future events that cannot be predicted with certainty, and where judgement about the issue depends on how to weigh or give value to the various information that is known about the issue (Dearden, 1981). The argument often focuses on what should be done about an issue but is usually underpinned by differences in key beliefs or understandings about the issue held by the protagonists.

Fleming (1986a) framed the analysis of socioscientific decision-making using a domain account of knowledge. He concluded that knowledge of the social world, as opposed to the physical world, was the most important determinant of children’s reasoning: “Adolescents define socioscientific issues in a way which stresses the social aspects of the issue” (Fleming, 1986b, p. 680).

Prime (1993) identified the relationship between technology practice and society as “it is only an informed and technologically literate citizen who would be able to make decisions about technology and assess its broad social impact on family structure, inter and cross-cultural relations, national and international functioning, its economic impact on business, commerce and government, as well as its environmental impact on agriculture, food production, and waste disposal, in both the short and long term” (Prime, 1993, p. 32).

According to Pavlova (2005b), social change is a very complex and dynamic phenomenon that can be considered from a variety of perspectives and is reflected in a number of processes. These processes are different in different types of societies. Traditionally, technology has been viewed as a cause or as an independent variable with social change as the consequence. Nowadays technology, as stated by Bohme (1992) has:
“Penetrated the social structure, the forms of social action and normative expectations. More to the point, technology has itself become a social structure, a form of social action and a part of the norms of action … It is no longer a question of technology as a cause or object but a question of the technological forms of social life.” (p. 39)

Pavlova (2005b) pointed out that people are integrated into a technological world, the world where almost everything depends on technology. In this type of society action oriented to success, a purposive-rational action, which is either instrumental or rational, or their conjunction is the leading factor of being in the world. This technologically based society has an influence on children’s lives and therefore on children’s decision-making strategies.

The attitudes of children towards technology and science might affect their beliefs about the influence that science and technology have on society. Jones (1997) argued that children have a positive attitude about technology, but they have an incomplete notion of technology. Fleming (1986a) and Aikenhead (1985) found that children believed that science affects society in more positive ways than technology. According to this research, some high-school children believed that both scientists and engineers were more capable of making decisions about public issues related to science and technology than the general public (Aikenhead 1985; Cajas, 2002; Fleming 1986a, 1986b).

According to Davies (2001), it is through the connections of scientific concepts, technological applications, and the impact on the global environment and the effect on society as a whole that children can be encouraged to engage in action thinking. This develops an appreciation of the complexities of decisions, interests, values and influences that contribute to the world in which children live.

Pavlova (2005b) suggested that social change can be addressed through design and technology education. She identified several issues, where it is possible to help children to be part of the social change: the involvement of children in democratic debates on the future outlines of technological development; development of their social and ecological sensitivities; helping them to distinguish real needs from desires; putting more emphasis on other than the aesthetic aspects of life that can provide existential meaning for people; developing an active/creative attitude towards problems (not re-active); teaching children to formulate problems (not only being involved in problem solving); challenging consumer oriented design;
looking at design as one source of inspiration, not as a source of economic utility; and developing social responsibility (Pavlova, 2005b, p.199).

Davies (2004) pointed out that it is important that young people try to be objective in making judgements about their own products and products made by others. According to Davies (2004), understanding these relationships between design, technology and society is a significant aspect of children’s preparation for citizenship and of making decisions about the kind of world they want to live in and the kind of world that they have now.

Design and technology provides opportunities for children to develop an awareness and understanding of the importance of making informed choices that contribute to the development of society (Davies, 2004; Pavlova, 2005b). Learning about current issues, not only enables children to understand the processes and technologies used for a particular product, but also encourages them to become more reflective about the impact of technological activities on people, society and the environment. Such awareness enhances children’s thinking in being more critical and making informed decisions as designers, makers or citizens (Patronis, Potari and Spiliotopoulou, 1999). At the same time, society itself will influence children’s design decisions as well, and therefore this is a two-way process from an early age (Kennett and Stedwill, 1996).

2.9. Teachers’ Roles in Children Decision-Making

Teachers have an important role in children’s learning through the activities that they employ in their school class. Their teaching methods, the autonomy that they give to children and their own ideas about the national curriculum are only some examples of factors that will affect children’s learning. Especially, in design and technology where there are so many diverse issues (design tasks, content knowledge, health and safety etc.) that the teachers need to manage, their decisions on the approaches that they take will possibly have an influence on children’s design decisions (Pajares 1992).

Davis and Krajcik (2005) explored how curriculum materials promote teacher learning and they argued that teachers were expected to teach meaningful content that helped children to meet learning goals in the context of authentic activities, while addressing the needs of diverse learners and ensuring children’s successful learning. The existing literature acknowledged that
teachers’ views of teaching and learning, as well as their beliefs about knowledge and intelligence had a direct impact on the way they used to teach (Pajares 1992).

Rohaan et al. (2008) and Rohaan et al. (2010) suggested that teachers should be able to combine subject matter knowledge and pedagogical knowledge for effective coaching of pupils’ learning processes. This implied that teachers’ should know about particular subject-related difficulties and should know how to handle these difficulties. This specific area of teacher knowledge is called ‘Pedagogical Content Knowledge’ (PCK) and was first examined by Shulman (1986). He defined it as “a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding” (Shulman 1987, p. 8). In other words, PCK is the knowledge of how to teach the content effectively. Teachers need to make connections between ideas, in addition to adding new ideas about subject-area concepts, instructional approaches, children’s likely ideas, or teaching principles (Ball and Bass, 2000).

According to Davis and Krajcik (2005) teachers must know how to help children understand the authentic activities of a discipline, the ways knowledge is developed in a particular field, and the beliefs that represent a sophisticated understanding of how the field works. Petish (2004) argued that design and technology teachers need to make use of PCK for disciplinary practices that would help them to engage children in the essential features of designing such as identifying technological problems, investigating possible solutions and justifying their design decisions. According to Hamilton (2007) teachers acted both as facilitators and resources within the dynamics of the interactional process. As an active and responsive participant, the teacher can become a significant catalyst for effective learning.

Research studies (Anning, Jenkins and Whitelaw, 1996; Banks, Leach and Moon, 1999; McCormick, 1990; McCormick, Murphy, and Hennessy, 1994) have shown that teaching can be influenced by factors such as prioritising management and accountability (McCormick et al., 1994); teacher beliefs (McCormick, 1990, p. 41); teachers’ pedagogic knowledge (Banks et al., 1999, p. 94); problems of curricular choice and coverage (Anning et al., 1996, p. 6) and classroom and school administration expectations (Banks et al., 1999, p. 90).

Hallam and Ireson (1999) pointed out that teaching is an interactive process in which teacher actions affect children’s reactions and vice versa. Hallam and Ireson (1999) illustrated the interactive nature of teaching in their model of teaching and learning (Fig. 2.5). The model
illustrates the reciprocity of teaching and provides a basis for understanding how a learning process might work. They illustrated effective teaching as a complex cycle of actions and reactions by the teacher, based on understanding of where children are starting from in their learning (the left side of the model). All aspects of teaching inform and are informed by the interaction between teacher, learner, teaching actions and learning outcomes. In their point of view (Hallam and Ireson, 1999) effective teaching depends on how the teacher facilitates such interaction and how learning tasks are ordered to ensure that the needs of the children are voiced, explored and fed back into the learning activities.

The Hallam and Ireson’s (1999) model describes how teaching should be organized to support learning, providing for teacher actions based also on the emerging information from children as they engage in activities; therefore, it gives children an important role in learning. McNair and Clarke (2007) argued that this model is suitable for design and technology educators but it is general and therefore requires careful interpretation in a design and technology context.

The important roles of teachers in the teaching and learning of design and technology have been reported by many researchers (Banks et al., 2004; Barlex and Rutland, 2003; Cross, 2006, Nicholl, 2004). Barlex and Rutland (2003) suggested that during a series of lessons in design

Figure 2. 5 - Model of teaching and learning (Hallam and Ireson, 1999, p. 79)
and technology, there will be pedagogical opportunities for whole class teaching, small group teaching and working with individual children. Through these opportunities, there will be numerous different tactics that the teacher can use, such as asking questions, modelling appropriate behaviour, and connecting different elements of the learning. The exact way in which these are carried out will provide a pedagogy that supports a design-based approach to food technology.

Rutland and Barlex (2008) indicated that the quantity and quality of creative problem solving is directly influenced by the design problem set by the teacher and the structuring of lessons. They concluded that the teacher was the key factor in fostering creativity by influencing pupils. According to them a key factor in their study was the ability of the teacher to provide a secure, rewarding, supportive, well-resourced and safe classroom environment where pupils were encouraged to take risks and work co-operatively (Rutland and Barlex, 2008).

Nicholl (2004) also pointed out that an important aim of design and technology teachers is to transform knowledge of their subject into what Shulman (1987) termed pedagogical content knowledge. According to Cross (2006) teachers’ thinking about teaching is influenced by their understanding of the nature of learning and knowledge. Rutland and Barlex (2008) pointed out that teaching strategies which influence the procedures and processes followed by the pupils are crucial. In addition, the teachers should manage and organise their classroom to ensure that the social and cultural environment is conducive to creative activity.

Nicholl (2004) argued that design and technology teachers’ interpretation of the domain is being developed by, among other things, their values, beliefs, attitudes and understanding of designing and creativity. By the same token Jones (2003) pointed out that design and technology teachers’ existing ideas in terms of teaching and learning, subject area, and school, together with their concepts of technology, influence the development of classroom environment and strategies, and consequent student activities.

Banks et al. (2004) developed a model of professional knowledge from a design and technology point of view (Figure 2.6). Based on Shulman’s work, they referred to a teacher’s ‘Professional Knowledge’ in terms of four interlinked clusters of knowledge; Subject Knowledge, Pedagogical Knowledge, School Knowledge and at the centre of the three the teacher’s Personal Subject Construct.
Figure 2.6 - Taken from the CReTE ‘teacher knowledge’ tool (Banks et al., 2004 p.143)

The model (Figure 2.6) is presenting the different aspects of teacher knowledge in design and technology education. Banks et al. (2004) suggested that the ‘school knowledge’ is intermediary between subject knowledge (knowledge of technology as practised by different types of technologists for example) and pedagogical knowledge as used by teachers (the most powerful analogies, illustrations, examples, explanations and demonstrations). Teacher’s subject knowledge is enhanced by his or her own pedagogy in practice and by the contextual expectations which form part of their school knowledge. According to Banks et al. (2004) “It is the active intersection of subject knowledge, school knowledge and pedagogical knowledge that brings teacher professional knowledge into being” (p.144). In the centre of this process are the ‘personal constructs’ of the teacher, a complex amalgam of their past experiences of learning, a personal view of what constitutes ‘good’ teaching and a personal belief in the purposes of the subject (Banks et al., 2004).

2.10. Children’s Decision-Making Opportunities in Design and Technology Education

Rutland and Barlex (2008) in their study with 11-14 year old children in the UK suggested that the role of the teacher and their impact on promoting pupil’s creativity is central in that they are the ‘gate keepers’ who sanction what should be included in the subject domain, for example making judgments about pupils’ work. They considered the important issues to focus on the teaching strategies of the teacher which influenced the procedures and processes followed by the pupils. Rutland and Barlex (2008) argued that teachers have an influence on pupils’ learning and the development of their skills: “the teacher is at the centre of a dynamic process and it is
their ‘personal constructs’, a complex amalgam of their personal beliefs and past experiences that underpins their professional practices” (p.140).

Barlex and Miles-Pearson (2008) argued that when the pupils were given the opportunities to express themselves freely with their design projects, it was found that they faced difficulties in making design decisions due to their lack of experience. When pupils have the opportunity to peer-mentor their fellow classmates as they learn and together with the presence of the class teacher, this might encourage and enable pupils to develop more diverse solutions.

Rutland and Barlex (2008) argued that “the teachers should manage and organise their classroom to ensure that the social and cultural environment is conducive to creative activity” (p.143). Similar ideas were expressed by Trebell (2008) who suggested that classroom activities that are giving to children greater independence, risk-taking and intrinsic motivation, empower pupils in their learning.

Researchers highlighted the importance of proper educational environments in teaching and learning. Hamilton (2007) pointed out that effective teachers aim to provide an educational environment that supports pupils in their learning. According to Morganett (1991) good teachers are not only knowledgeable about their subject but, more importantly, they care for their pupils as individuals, show respect for their ideas and value their contribution to the interactive process.

Additionally Trebell (2009) argued that the pedagogic strategies adopted by the teacher either facilitates designerly decision-making or prevents it. She pointed out that enabling pupils to make a broad range of design decisions is an essential feature of the classroom interactions which support the development of designerly activity by inexperienced child designers (Trebell, 2009).

The teacher-pupil interaction is part of every teaching and learning activity in schools. Black (2008) designed a graphical model of the two-way interaction, between the teacher addressing a question to the learner, and the learner responding to the teacher (Figure 2.7). The two arrows are broken, to indicate that what is understood by the listener is not always the message that the originator intended. Thus, according to Black (2008) it is important for the teacher to listen very carefully to any response, and to take time to think about how the learner came to make
such a response, for it is only in terms of this diagnosis that the teacher can decide how best to frame his or her next intervention.

Figure 2. 7- A simple model of formative interactions (From Black, 2008, p. 22)

Stables (1995) investigated the transition from Year 6 to Year 7 and she concluded that there was a gradual shift from the case that the teacher initially being in charge of the project (through direction); through an intermediate phase where pupils started to take control by getting the teacher to affirm the decisions that the pupil proposed to take; to a final point where pupils were taking the majority of decisions.

Figure 2.8 shows how Stables (1995) observed the classroom activities patterns that emerged from her study. In the research, Stables (1995) used pre-coded data for each five minute interval where a teacher/pupil interaction was recorded and was designated either 'teacher predominantly in control' or 'pupil predominantly in control'. Figure 2.8 indicates the proportion of intervals falling into each category, and how these proportions shifted across the length of the project (Stables, 1995).
The key role of teachers in the learning process is acknowledged by evidence from children as well. In Rutland and Barlex (2008) study, most pupils considered the role of the teacher as important in creating a supportive atmosphere, where pupils developed knowledge, understanding and skills in materials and techniques and as a result, they made informed choices.

Rutland and Barlex (2008) suggested that the teacher was the most important factor in fostering creativity by influencing pupils. Rutland and Barlex (2008) pointed out that “a key factor was the ability of the teacher to provide a secure, rewarding, supportive, well-resourced and safe classroom environment where pupils were encouraged to take risks and work co-operatively. The role of the teacher was seen in the case study as the crucial factor for successfully fostering creativity rather than any differences there may be across the specialist areas of the design and technology curriculum” (p. 160).

In addition to the importance of teacher - children interaction, Schaffer (1996) suggested that peer to peer mentoring can improve a wide range of educational and professional training activities. Vygotsky’s ideas of cognitive development have placed major emphasis on the
A. Mettas PhD 2011

Chapter 2: Literature Review

supportive and cooperative role of the child’s partner (Schaffer, 1996). Bendelow and Mayall (2000) found that for the majority of children, friendships and companionships are critical to their enjoyment, together with work in which they could participate actively.

Kimbell and Perry (2001) argued that the real products of design and technology classrooms are to be seen not only in terms of ‘3D artefacts’ that pupils produce but rather the ‘empowerment’ of children. If learner empowerment is the goal of teaching design and technology, then the challenge for teachers is to provide more authentic instructional contexts that will motivate and stimulate pupils in their learning and give them a real sense of ownership and personal achievement (Hamilton, 2007).

Rutland and Barlex (2008) reported that design and technology teachers (and art and design teachers) observed that there was a minority of pupils who were self-motivated in order to be creative and the majority of them who needed support and guidance from teachers. From the literature, it emerged that a framework of strategies for pupil motivation and stimulation would be helpful, though acknowledging that some teachers would require guidance and support in their use. The use of group and team work with peers was seen as especially effective (Rutland and Barlex, 2008). Hill (2007) mentioned a number of important factors that are influencing students’ motivation to learn, for example, contextualization learning in the students’ world, bringing real-world subjects into the classroom, giving the students choice, autonomy and control over their learning, and providing feedback.

Fox-Turnbull (2006) suggested that an important issue about the nature of activities that children undertake is that authentic learning engages children and encourages learning. According to Hennessy and Murphy (1999) “activity is said to be authentic if it is (i) coherent and personally meaningful and (ii) purposeful within a social framework – the ordinary practices of culture.” (p. 8).

2.11 The Role of the Curriculum in Children’s Decision-Making

According to Prideaux (2003), the curriculum represents the expression of educational ideas in practice and includes all the planned learning experiences of a school or educational institution. Although the largest part of school teaching is based on the content of the curriculum, in practice there will be some ‘unplanned’ learning activities as well, those that derive from outside the curriculum.
Prideaux (2003) pointed out that “the curriculum must be in a form that can be communicated to those associated with the learning institution, should be open to critique, and should be able to be readily transformed into practice” (p.268). Davis and Krajcik (2005) pointed out that curriculum designers “must ensure that the curriculum materials are accurate, complete, and coherent in terms of content and effective in terms of pedagogy, with good representations of the content, a clear purpose for learning it, and multiple opportunities for children to explain their ideas.” (p.3).

Prideaux (2003) suggested a curriculum has at least four important elements: content; teaching and learning strategies; assessment processes; and evaluation processes. The process of defining and organising these elements into a logical pattern is known as curriculum design.

From the review of the literature there is limited empirical work that has been done in the role of curriculum materials and their actual effect on teaching. Some of the studies suggested that educative curriculum materials could help teachers learn how to anticipate and interpret what learners may think about or do in response to instructional activities (Ball and Cohen, 1996), describing why children might hold particular ideas (Heaton, 2000) and giving suggestions on how to deal with those ideas (Collopy, 2003), as well as giving teachers additional support for pedagogical content knowledge (Wang and Paine, 2003).

Despite the obvious advantages of curriculum materials, there are some disadvantages as well. Davis and Krajcik (2005) argued that curriculum effectiveness is limited (or enhanced) by characteristics of the teachers themselves, such as their knowledge, beliefs, and dispositions toward reflection and improving their own practice (Collopy, 2003; Schneider and Krajcik, 2002). According to Davis and Krajcik (2005) educative curriculum materials are not likely to support learning for every teacher.

The curriculum essentially determines the goals of design and technology education. For example, in the English National Curriculum (DfEE 1999), design and technology is said to prepare pupils to participate in tomorrow's rapidly changing technologies. They are to learn to think and intervene creatively to improve quality of life. The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team (DfEE 1999, p.15).
Barlex and Rutland (2003) argued that “the key to progression is the nature of the design decisions that the pupils are expected to make. The designing and making activities are formulated so that there is increasing demand in these design decisions over time; so that in principal progression can take place” (p. 190).

Jones (2003) described the development of a technology curriculum in New Zealand that emphasised a child centred curriculum, one that is central to human experience, values, culture, and social forces. According to Jones (2003), “technology education had to be defined within the social, educational and economic environment. Community values, socio-cultural and economic activities, as well as individual needs for knowledge, skills, and experiences, play a significant role in determining the content of technology education” (p. 88).

The importance of classroom and curriculum organisation and management by the teacher, as noted in the study of Rutland and Barlex (2008), emphasized the need for a calm, supportive environment conducive to confidence and risk taking.

2.12 Transfer of Design Decision-Making Skills

According to Butterfield and Nelson (1989), one of the important targets of each educational system is to enhance the ability of children to transfer their knowledge and skills from one area to another. Singley and Anderson (1989) defined transfer at the individual level as “how knowledge acquired in one situation applies (or fails to apply) to another”(p.1). Butterfield and Nelson (1989) suggested that promoting transfer is the fundamental goal of teaching, because contexts and purposes change, and people are severely handicapped if they do not adapt their past learning to new circumstances and intentions.

The concept of transfer has been under considerable debate by many researchers (Mestre, 2005). Some researchers believed that transfer rarely occurs (Detterman, 1993), others believed that it is an unfeasible concept (Hammer et al., 2005) and others considered it as ubiquitous (Dyson, 1999). Other research studies suggested that there is little evidence to support the existence of skills' transfer (Brown, Campione and Day, 1981; Carraher and Schliemann, 2002; Gick and Holyoak, 1980; Welch, 2007). Components of thinking such as skills and strategies, may be specific to the content, and tied to the context in which they were learned (French and Rhoder, 1992). Carraher and Schliemann (2002) identified that ‘there is
little evidence for some monolithic skill or piece of knowledge being carried over intact from a unique prior situation to the present one’ (p.19).

In education, transfer of learning means the extent to which learning is transferred from one context to another. According to Gagne et al. (1993) the “transfer is the application of knowledge learned in one setting or for one purpose to another setting and/or purpose” (p.235). McCormick (1999) suggested that transfer of learning can occur in the case were prior-learned knowledge and skills affect the way in which new knowledge and skills are learned and applied.

According to French and Rhoder (1992) knowledge within a domain, such as problem-solving in mathematics, often remains inert, even though it may aid learning of new information. Gick and Holyoak (1980) have shown that transfer of knowledge, of how to solve a particular problem to aid in the solution of a second analogous problem, is not always automatic. In addition Brown, Campione and Day (1981) have found that knowledge of particular learning strategies themselves, such as categorization and rehearsal, may often be inert.

The reason for the difficulty in transferring the knowledge and skills from one domain to another according to French and Rhoder (1992) is that knowledge of a particular procedure, i.e. problem solving, when taught within a specific domain, e.g. mathematics, results in the generation of specific domain-related schema for solving those problems. These schema are not spontaneously transferable to a new domain. These specific-domain schema are a kind of inert schema, not easily accessible from other fields (French and Rhoder, 1992).

French and Rhoder (1992) suggested that there is no definitive agreement on whether thinking skills and strategies are generic or whether certain ones are more important for particular content or whether particular content requires particular skills. However, if spontaneous transfer of specific, generic thinking skills and strategies from domain to domain is one of the goals of teaching and learning then different approaches to instruction in terms of this goal need to be evaluated.

Bereiter (1995) considered transfer to be ability and not a process, with the potential for transfer lying with the learner, rather than in what has been learned. Bereiter (1995) argued that teaching should focus on character education, so that learners are able to think about situations rather than try and reproduce their learning. Bereiter (1995) supported Lave and Wenger’s
(1991) work who argued that people learn by entering ongoing ‘communities of practice’ and gradually work their way into full participation.

According to McCormick (1999), “most of us no doubt assume that knowledge is in the head, and that we dig it out of our memory banks to use it for some task. There are, however, a collection of approaches to cognition and learning that argue that the knowledge is integrated with activity, along with the tools, sign systems and skills associated with the activity. In this sense knowledge guides action, and action guides knowledge” (p. 9).

In the area of design and technology few studies have investigated the issue of transfer. In Rutland and Barlex (2008) study about pupil creativity in design and technology in the lower secondary curriculum in England, there was limited reference to pupils’ previous personal or educational experiences and a lack of links with other subjects in the curriculum.

Givens and Barlex (2001) argued that design and technology education seeks to teach a set of generic design skills in such a way that they become transferable. As a result, “pupils who learn a particular design skill (e.g. developing specifications) when they are working with textiles are able to access and use the skill appropriately when working at some later time with systems and control. If this is to take place, it remains important that teachers, curriculum developers and curriculum publishers present generic skills in such a way that transferability is optimised.” (p.157). The related literature on transfer of knowledge and skills has suggested that transfer is not easy (Hennessy and McCormick, 1994; Levinson et al., 1997; McCormick, 1999).

The findings from research (Glaser, 1992; McCormick, 1999) suggested that problem solving skills are dependent upon considerable domain knowledge. Thus, rather than it is considered to be a general skill that can be used with similar success in a variety of areas, it requires expertise in the context of its application. McCormick (1999) argued that “models of capability that assume problem solving or design are general transferable skills, whatever the particular context, do not represent how real problem solving and design take place. Those who solve problems rarely resort to general processes” (p.7). Research did not support the idea of general transfer of skills and it did not also support the teaching of problem solving as an abstract general-purpose process (Hennessy, McCormick, and Murphy, 1993).

McCormick (1999) argued that transfer is as a process, where the learner plays a key role. The transfer process involves a number of contributors, primarily the learner, the educator or
facilitator and the colleague or manager, who play different parts in the various phases of the transfer process – before, during and after initial learning.

2.13 The History of Design and Technology in Cyprus

Since the current research is exploring the development of children’s design decision-making skills in Cyprus, a short description of the subject of design and technology in Cyprus will set the context of the study.

Design and technology education was first introduced and taught in general secondary schools in Cyprus through an agreement between UNICEF and the Government of Cyprus and concluded in 1967. The project was implemented in four pilot schools from 1967 to 1969 and the new subject was called “Practical Knowledge”. It was very much on the lines of “Handicraft” taught in the U.K and consisted of woodwork, metalwork, technical drawing and practical electrics. It was offered only in the three years of lower secondary schools (Gymnasia) to boys aged 12 -15 years. Girls were offered Home Economics.

Teachers called upon to teach Practical Knowledge were elementary school teachers who took summer courses in handicrafts. Subsequently, within four years (1969 - 1973), the project was expanded to over twenty more Gymnasia. After this initial period covered by the above agreement, the Government of Cyprus proceeded to cover all remaining lower secondary schools. The scheme included the supply of basic equipment and the construction of new workshops. The project was partly suspended after the events in 1974 (Turkish invasion and occupation of northern Cyprus) and, though the subject remained in the Gymnasia curriculum, very little was done for its promotion after 1974 (Koutsides, 2003).

In 1988, a report prepared by the Inspector of Industrial Arts and Crafts in Cyprus proposed that the subject of Practical Knowledge in the Gymnasia needed to be upgraded. The report outlined the weaknesses (absence of research and creativity in children's work; low morale of teachers; unsatisfactory condition of workshops; discrepancies in teachers' qualifications) of the existing system and suggested the adoption of a new curriculum and implementation procedures (Koutsides, 2003). Similar views were also expressed by overseas experts, one of them being the Bedfordshire Education Authority (U.K.), who, following a request from the Ministry of Education, developed a specific plan for introducing a new subject: design and technology. The Ministry of Education committee agreed with these views and in their own report, they
recommended that for pedagogical and economic reasons, priority should be given to the introduction of the new subject of design and technology education, replacing the existing subject of Practical Knowledge in which research and design, the indispensable elements in technology teaching, were absent.

A scheme for upgrading technology education in the Gymnasia was thus included in the five year development plan 1989 – 93 on an experimental basis. At the same time, the Ministry of Education submitted its proposal to the Council of Ministers for the construction of new workshops, the purchase of new tools and equipment, the provision of training courses for old and new technology teachers, etc. Under the same proposal, the British Overseas Development Administration would offer technical assistance for the implementation of the proposed scheme, particularly to train teaching staff (Koutsides, 2003).

In 1990, a new subject named design and technology (D&T) was introduced on a phased basis to replace Practical Knowledge. It was to be offered to both boys and girls in all three years of the Gymnasia (children aged 12-15). As stated in the 1989 committee report, the main aim of the new course was to provide a stimulating, educational environment in which children can acquire and develop knowledge and capability skills and attitudes through designing and making, which will enable them to live and work in a changing technological environment. Though the model of D&T in Cyprus followed the English example, it was adapted to local circumstances. Children were to be given the opportunity to design and make products mainly using resistant materials and to produce systems involving electric/electronic circuits, mechanisms, pneumatics and structures (Koutsides, 2003).

Following the recommendation of the Bedfordshire report that new teachers of D&T be degree holders, it was decided to organise a two-year course for every newly appointed teacher with an engineering background as there were no graduates in design and technology education at the time. The 1990-93 course, organised by Bedfordshire working closely with the Inspectorate in Cyprus, was attended by the existing Handicraft teachers (ex-elementary school teachers) and about 30 engineers, specially appointed to teach the subject. In the succeeding years the course was not continued as Cypriot degree holders in D&T had already started returning to Cyprus after their studies in the U.K.

The subject was introduced in primary schools in 1995 on a pilot basis and in 2000 the subject was extended to all primary schools. From the academic year 2000 – 2001, the subject has
been introduced into upper secondary schools (15-18). It acquired a more theoretical background (design and making is only small part of the subject and more content based issues are involved) compared to the design and technology of Gymnasia because children are expected to take exams on a specific syllabus during their last year in school. All school subjects are compulsory in the first year. But by the end of the first term, children must select four as majors for the second and third years. Technology is taught twice a week in the first year and four times/week in the second and third years. Some of the areas of study included were: mechanisms, electronics, ergonomic design, telecommunication, robotics, pneumatics and structures.

The overall aim of the subject is the creation of an educational environment that challenges children to solve practical problems. Children are taught to develop their design capability by combining design and making skills with knowledge and understanding in order to design and make a product. In this attempt children must use their judgment, creativity and knowledge to solve a specific problem. A detailed description of the Cypriot National Curriculum will be presented in Chapter 4 (pilot study results).

### 2.14 Brief Description of Design and Technology Education in Cyprus, England and Iceland

This section will first describe briefly the subject of design and technology education in Cyprus, England and Iceland and then present a comparison of the national curricula of design and technology education in those countries since the research is to be undertaken in those countries.

Design and technology education in Cyprus was introduced in 1992 and replaced a craft based subject. Children were to be given the opportunity to ‘design and make’ products using mainly resistant materials and create systems involving electric/electronic circuits, mechanisms, pneumatics and structures. The subject is compulsory for children in primary schools aged 5 - 10, for children in lower secondary school, aged 12-15, and for the first grade of higher secondary school, aged 15 and is optional for second and third grade of upper secondary school, aged 16 and 17.

Design and technology in England was introduced in 1990 following development over a number of years, and with an emphasis on designing and making activities. In design and
technology classes, children are expected to combine practical and technological skills with creative thinking to design and make products and systems to meet human needs. Such learning about available material and technologies is expected to support their participation in developing positive attitudes about technology. Design and technology in England is compulsory for Key Stage 2 (ages 7-11) and Key Stage 3 (ages 11-14) and is optional for Key Stage 4 (age 14-16).

The Icelandic “Craft” subject was re-established as a new technological subject in 1999, based on a rationale for technological literacy, innovation and design. The new subject “Design and Craft” was influenced by the national curricula of New Zealand, Canada and England and a specific Icelandic model for Innovation Education. Design and Craft education is compulsory for all grades 1 – 8 (ages 6-13), but optional for grades 9 – 10 (ages 14-15). In this subject children base their ideation on authentic problems and design, make their design products from resistant materials and they design systems based on electric/electronic circuits, mechanisms, pneumatics and structures.

In England, design and technology includes home economics (food technology and textiles), whereas in Cyprus and in Iceland home economics and design and technology are separate subjects. For the purposes of the current study, the curricula of Key Stage 3 (age 11-14) in England, the lower secondary education (Gymnasium, age 11-14) in Cyprus and grades 7-9 (age 11-14) in Iceland have been compared in terms of decision-making opportunities provided to children in design and technology.

**Summary**

The literature review conducted in this Chapter describes possible factors that are involved in children’s decision-making in the area of design and technology education. Literature on the cognitive development process in children, decision-making strategies, the role of knowledge, skills, values, the effect of society, teachers and curriculum materials in terms of decision-making have been reported. From the literature reviewed, it can be concluded that children’s decision-making processes are complex and affected by many factors. With this foundation, the design of the research is taking into account all the identified factors that influence children’s decision-making as they emerged from the literature reviewed. The review of the available literature in relation to possible research methods will formulate the research design of the study that follows in the next chapter.
Chapter 3: Research Methodology

Overview: This chapter discusses the research methodology employed in this study, the research strategy, the selection of participants and the methods used for data collection. At the end of the chapter proposals for the data analysis are presented.

3.1 Research Approach

Within the educational research there exists no unanimity among researchers concerning the choice of research approach. Some researchers employ quantitative approaches (Furby and Beyth-Marom, 1992; Nisbet and Grimbeek, 2004), while some others adopt qualitative approaches (Mioduser and Kipperman, 2002). Cohen et al. (2007) assert that the choice of research approach must be guided by the question: “how can research questions best be answered?” (p.3).

According to Robson (2002), in-depth information is necessary for revealing a complex and dynamic issue such as children’s decision-making strategies. For the purpose of the current study, it was decided to use a mainly qualitative approach, as this approach can provide more informative data for answering the research questions (analysed in Chapter 1). Despite the generally qualitative approach, some quantitative methods are also used and pre-tests and post-tests will be conducted in order to enrich our data. As Cohen and Manion, (1994) argued, qualitative research enables the researcher to construct an insider’s perspective, which is important for obtaining a better insight of the participants’ viewpoints. The approach to the study has been situated within action research methodology (McNiff and Whitehead, 2000). The theoretical background of action research and its appropriateness for the current study will be analysed in the following sections.

3.2 Action Research

Action research is becoming increasingly known as an approach that encourages practitioners to be in control of their own lives and contexts. It began in the USA, came to prominence in the UK in the 1970s, and by the 1980s it was making a significant impact in many professional contexts, particularly in teacher professional education. Now its influence is worldwide, and has
spread to virtually all areas where personal and professional learning is undertaken (McNiff and Whitehead, 2000).

Action research is a term which refers to a practical way of looking at your own work to check that it is as you would like it to be (Hammersley, 1993). Because action research is done by the practitioner, it is often referred to as practitioner based research; and because it involves thinking about and reflecting on your own work, it can also be called a form of self-reflective practice.

Action research is open-ended and it does not begin with a fixed hypothesis. It begins with an idea to be developed. The research process is the developmental process of following through the idea, evaluating the outcome, and continually checking whether it is in line with what you wish to happen. Seen in this way, action research is a form of self-evaluation. It is used widely in professional contexts such as appraisal, mentoring and self-assessment (McNiff and Whitehead, 2000).

The process of conducting action research means that you have to evaluate what you are doing. You need to check constantly that what you are doing is really working. This awareness of the need for self-evaluation shows your willingness to accept responsibility for your own thinking and action. Accountability is part of good professional practice. You are always aware that you have to give good service, to attend to the needs of others in the way that is best for them, and to show that you have responsible attitudes and behaviour (Zuber-Skerritt, 1992).

Action research helps you formalise your learning and give a clear and justified account of your work, not on a one-off basis, but as a continuing regular feature of your practice (McNiff and Whitehead, 2000).

Many writers have developed graphical models to represent the action research process. The common characteristic of those models is the cyclical process of action research and the reflection on new findings until an improvement is achieved. Lewin (1946) described the process of action research as a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the results of the action. His spiral model was later adopted by various action researchers. Carr and Kemmis (1986) applied the idea of action research exclusively to education and provided a detailed plan on how to use it in that context. Action research usually begins with the identification of a problem situation a need for changes and follows a self-reflecting spiral of planning, acting, observing and revision (Figure 3.1).
1. Identification of problem area
2. Planning
3. Acting
4. Observing
5. Revision

Figure 3.1 - Action research cycle (based on Zuber-Skerritt, 1992: 13)

Action research projects can be presented as comprising of several cycles of action and reflection or only one cycle (McNiff et al., 2003; McTaggart, 1996). A new action research cycle can then begin as new areas of investigation emerge. It is possible to imagine a series of cycles to show the processes of developing practice. The processes can be shown as a spiral of cycles, where one issue forms the basis of another and, as one question is addressed, the answer to it generates new questions (Hammersley, 1993; McNiff and Whitehead, 2000).

Action research has some limitations as well. Usually action research is conducted with small samples and in a specific environment and therefore its results may not be applied to similar cases in different environments. Another limitation is that the personal over-involvement of the researcher may bias research results. As Creswell (2007) states, researchers bring their own worldviews, paradigms, or sets of beliefs to a research project, and these inform the conduct and writing of the study. It is important that these assumptions, paradigms and frameworks are made explicit in the writing of a study, as they may influence its conduct (Creswell, 2007; Merrian, 2001).

### 3.3 Action Research in Design and Technology Education

Action research is recognised as one of the most productive and suitable types of research in design and technology education. This type of research has a long tradition in the field of design and technology and is acknowledged by the leaders in the area (Archer 1992; Green 1998; Norman 1999; Roberts 2000).
Design and technology and action research share many common processes. They both begin with the identification of a problem and go on with planning a solution, evaluate the plan and end with the best possible solution. Designers and action researchers both reflect on their work in order to improve practice. The solution may well be revised and be redesigned again. Archer (1992) describing the nature of research in design and design education, argued for the designerly activity as a mode of enquiry and he stated that:

“a designerly approach, rather than a scholarly or scientific approach, can with advantage be made towards educational research and curriculum development. Design, in a certain sense, is research done backwards. Research starts with the particular, and moves towards the general. Design starts with the general and works towards the particular. Designers are told, or decide, at the outset, what their end product must be and do. They begin by conceiving of one or more broad configurations that seem likely to be, and to do, what is required. They then elaborate the structure of these configurations and develop the subsystems of one or more of the most promising proposals. They then detail the construction, working backwards to the particular, the bits and pieces, upon whose correct construction depends on the efficacy of the whole. At various stages, the validity of assumptions is checked and performances are measured. The same basic design process can be, and is being, applied to the development of all sorts of artefacts and systems that had not hitherto been thought of as subjects for design.” (Archer, 1992, p.12).

The relevance of action research in design and technology is supported by Roberts (2000), who suggested that action research as a mode of inquiry and development is especially appropriate to D&T educational practitioners. He pointed out that the support of the teacher-as-researcher and the support of the position that action research within education in general and in design and technology in particular is intended to improve practice.

Green in her Keynote at the International Conference on Design and Technology Educational Research (IDATER 1998) suggested that: “the fundamentals of action research involve: the questioning of assumptions; the clarification of values; the discovery of the mismatches between espoused values and practice; the understanding of the wider social context in which I work.” (Green 1998, p.2).

Carr and Kemmis claims that the purpose of educational research is to take actions and wrote: "practical problems are problems about what to do their solution is only found in doing
something” (Gauthier 1963 quoted in Carr and Kemmis 1986). This argument is very relevant to many design and technology development activities in the school environment.

### 3.4 Action Research in Cyprus

Action research is also gaining a significant importance in the Cypriot educational system. Many research studies in the educational context have been conducted through an action research approach by teachers and educational policy developers (Angelides, 2002; Karagiorgi, 2002; Tsiakaros and Pasiardis, 2002). Karagiorgi and Symeou (2006) consider action research as one of the important issues that needs to be part of any educational professional development course in Cyprus. Angelides (2002) argues that staff development and in-service training should be repositioned towards action research that encourages teachers to scrutinise their own practice.

Karagiorgi (2002) points out the significance of action research in the Cypriot educational system. She supports the position that action research approach from teachers is the key to any effective innovation and improvement in schools. The importance of teachers as practitioners is recognized in the Cypriot National Curriculum (2006):

> "the teacher of each class has an important role for the assessment of the national curriculum, use of new teaching methods, the introduction of new technologies to the teaching process and generally any new change" (p. 33).

In a research study, Kyriakides, Campbell and Christofidou (2002) generated criteria for measuring Cypriot teachers’ effectiveness through a self-evaluation approach. The study was initially conducted by interviewing 14 teachers and ended up with eight categories of characteristics of an effective teacher. In order to examine whether the eight categories of criteria reflected the views of Cypriot teachers more generally, a questionnaire was designed and administered to a randomly selected sample of 20% of Cypriot teachers (N=682). A willingness to undertake action research was considered among the characteristics that an effective teacher should have. From the results of the study Kyriakides et. al. (2002) argues that:

> “an effective teacher takes part in action research projects and thereby contributes both to the implementation and evaluation of school-based curriculum innovations.”

(Kyriakides et.al 2002, p. 308).
3.5 The Action Research Plan

Because of all the reasons that have been described the decision was made to adopt an action research approach (a good researcher is aware of the limitations). The action research plan of the current research study is presented in Figure 3.2. Two action research cycles were planned, the first action research cycle was a pilot study, and after revising some of the data collection methods the plan was developed and implemented again for the main study.

The objective of the study was to explore how children develop decision-making skills in design and technology education. Therefore the starting point of the research cycle was to review existing literature and national curricula. Existing literature was searched with using keywords from scientific databases with journals and books. National curricula were examined in relation to their requirements about decision-making and the opportunities that they offer to teachers and children. In addition the current practice of teachers was investigated. The next step required children to work with specific decision-making tasks and during that step, data were collected through observations and interviews. The observation and interview protocols were based on literature reviewed and several discussions with academics, other teachers and children. The data analysis and the interpretation that followed provided a valuable framework to revise and then repeat the research plan for the main study (the second action research cycle).

Figure 3.2 - Action research plan on the development of decision-making skills
3.6 Research Design

The research process of the study was defined as action research because of the appropriateness of the specific method to examine current practice. To be able to explore children’s ideas in depth, it was decided to use mainly qualitative methodology, although some quantitative methodology was used for example pre-tests and post-tests. The benefit of qualitative methodology is that it allows for categories to be developed inductively from data and observations (Merriam, 2001).

The study’s methodological perspective was continually open to review. This is consistent with action research and qualitative analytical techniques concerning the relationship between data and research issues, as well as contributing to the continual revision of the assertions emanating from the study (Patton, 1990; Ritchie and Hampson, 1996). The research progressed through a pilot study before the main study. The pilot study was a smaller version of the main study and was conducted to prepare the data collection methods for the main study. In the pilot study a pretesting of a research tools such as interviews and observations occurred.

3.6.1 Pilot Study – The First Action Research Cycle

The term 'pilot studies' refers to mini versions of a full-scale study, as well as the specific pre-testing of a particular research instrument such as a questionnaire or interview schedule. Through that process the researcher gains experience in the use of the instruments. Pilot studies are a crucial element of good research design. Conducting a pilot study does not always guarantee success in the main study, but it does increase the likelihood of success. Pilot studies fulfil a range of important functions and can provide valuable insights for other researchers. Silverman (2000) suggests that the effectiveness of the data collection tools can be enhanced by carefully piloting them. Based on the research questions the pilot study was divided into a number of steps and processes that are presented in Figure 3.3.
The first phase of the pilot study included interviews with teachers from Cyprus, England and Iceland, and the review of national curricula and teaching resources in those countries. The aim was to understand how cultural differences may affect teachers’ ideas about decision-making and consequently a comparative study of practice was designed (research question 1). England was selected as a country where design and technology education is well established in the national curriculum, and the English model has inspired many other countries to establish similar subjects. Cyprus and Iceland are both small islands that were influenced in a way by the English model of design and technology, and which might reveal such cultural differences. Cyprus was selected since it is the home country of the researcher and the main research will be undertaken there. Iceland was selected because at the same time that the researcher was doing his research at Loughborough University, another researcher from Iceland with similar research interests was studying there as well and he was willing to contribute to the study.

After the interviews and the review of existing practice a specific decision-making task was designed and given to children (the actual task is shown in Appendix 3.1). The theme of the task was to design and make a moving picture using levers and linkages. This particular task was used in the pilot study because during the period that the pilot study was taking place, this specific type of mechanism was required by the Cypriot curricula of design and technology. Despite the defined project, children had to take the following design decisions:
• what the moving picture will be about;
• what images the moving picture will contain;
• which parts of the picture will move;
• the suitable type of mechanism that will give the desired movement;
• any additional features for the decoration of the picture.

Children recorded and justified their design decisions in their log-books as shown in Appendix 3.2. During that period open observation of children while designing was taking place (research questions 2 and 3). The purpose of this kind of observation was to identify the factors that were involved in children’s decision-making in practice without any pre-set criteria. The outcomes of this open observation guided the development of a semi-structured observation in the main study.

After the task was completed, a test was administered to the children with decision-making opportunities not directly relevant to design and technology activities. The purpose of that procedure was to gather information about children’s ability to transfer their skills learned in design and technology classes to other activities (research question 4). The last section of the pilot study consisted of a semi-structured interview after the children had finished with the decision-making tasks set to them. In semi-structured interviews, the interviewer had a predetermined questionnaire but was free to modify the wording and order of the question to some extent (Robson, 1993). Explanations were given about the questions, while particular questions which seemed inappropriate with a particular interviewee could be omitted and additional ones could be included (Robson, 1993). The rationale for that step was to shed further light on some specific areas of practice during their decision-making tasks (research questions 2, 3 and 4).

### 3.6.2 Selection of School and Participants of Pilot Study

The children involved in the pilot study were drawn from a public secondary school of 510 children and 52 teachers, serving an urban area in Nicosia, the capital of Cyprus. This school was purposefully selected, because the researcher used to work there as a teacher at the time that the research was conducted. Thus, it was easier to gain access and approval for the research. Information about the nature of the two classes are shown in the Table 3.1. Table 3.2 presents the number of participants and the duration of the data collected in the pilot study.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of children in class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A class (aged 12-13)</td>
<td>30 (16 girls, 14 boys)</td>
</tr>
<tr>
<td>B class (aged 13-14)</td>
<td>29 (14 girls, 15 boys)</td>
</tr>
</tbody>
</table>

Table 3.1 - Characteristics of the sample of pilot study

<table>
<thead>
<tr>
<th></th>
<th>Teachers Interviews</th>
<th>Children Interviews (post-observational)</th>
<th>Observations</th>
<th>Post-test</th>
<th>Children Log-Books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
<td>N=12</td>
<td>N=15</td>
<td>N=59</td>
<td>N=59</td>
<td>N=59</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>20-25</td>
<td>15-20</td>
<td>(3X4X45)*</td>
<td>40</td>
<td>-</td>
</tr>
</tbody>
</table>

*(3x4x45) = 3 classes x 4 observations x 45 minutes each

Table 3.2 - Pilot study data collected

### 3.6.3 Main Study - The Second Action Research Cycle

After the analysis of data collected from the pilot study, the action research plan was revised taking into account the limitations and weaknesses revealed from the pilot study. The aim of piloting the data collection tools prior to the implementation in the field was to reveal the practical difficulties that could be raised in later parts of the research (Clough and Nutbrown, 2002; Robson, 2002).

More specifically, the following issues were considered for revising the data collection tools for the main study: (1) if problems existed with the wording of the preliminary survey instructions that were read to the participants by the researcher (2) if problems existed within the wording or nature of the tasks or interviews (3) the time needed to complete the pre-test, interviews and observation and (4) if the survey was capturing the information needed to successfully answer the respective research questions for this study.

During the pilot study, after the interviews and observations, the children provided feedback about the types of questions, their format and appropriateness (Robson, 2002), which helped to modify the interview and design the observation schedule. The pilot open-observation was not structured and its purpose was to gather information and factors that were involved in children’s
decision-making. At that stage of the research, our understanding on children’s decision-making behaviour while designing was limited. During the observation, the observers reported on field-notes the factors that were involved in children’s design-decisions. Based on the notes of the pilot observation, a semi-structured observation protocol was designed for the main study (Appendix 3.3). The new observation protocol included factors that are involved in decision-making both from literature review and the pilot observation notes.

Another change of the main study as compared to the pilot is the submission of a pre-test and a post-test before and after the decision-making tasks given to children. The emphasis of the test was on decision-making tasks from areas further than design and technology in order to explore the ability of children to transfer their skills to other activities. The design of the main study was modified based on the limitations and weaknesses of the pilot study and is presented graphically in Figure 3.4.

![Figure 3.4 - The design of the main study](image-url)
3.7 Ethical Issues

Ethical issues in research must be examined very carefully since children are involved in this study. The ethics of educational research has been significantly complicated over the last several decades as a consequence of the "interpretive turn" and the ever-increasing use of qualitative research methods that have accompanied it (Fontana and Frey, 2000; Thomas and Denton, 2006). In this section, the ethical issues that have been considered during the research are discussed.

Guidelines on ethical issues are provided usually from Universities, education authorities and national or international laws. In this study, national guidelines from the Ministry of Education of Cyprus were used together with the guidelines of the British Educational Research Association (BERA, 1992) and the Loughborough University guidelines, last revised in 2003. The above guidelines provided the framework of the study to ensure that the participants of the study will be protected.

Firstly, contact was made with the school head teacher and with the design and technology teachers of the school. The researcher briefly informed them about the study and they all expressed their interest in participating. Next, permission was requested from the Cypriot Ministry of Education, assuring them that all necessary processes regarding ethical issues will be followed. After the permission was given, a meeting with children and their parents was called to explain the purpose of the research, the methods and the recording equipment employed in the study. The children were also assured that participation was voluntary and anonymity was guaranteed (BERA, 2004). The purpose of the meeting was to obtain informed consent from the children and their parents (Mitchell, 1993).

Parents of children in the study were provided with a description of the study outline and were invited to contact the researcher if they had any questions. They were also requested to sign a consent form, while they received the name, the phone number and the email address of the researcher. Children and teachers were also informed about the names of the researcher and supervisor and the purpose of the study. They were informed about the timing and length of interviews, observations and tests, as well as their rights during the study. Specifically, they were informed that they could withdraw their participation at any stage of the project.
The name of the participating school remains confidential. Indeed, the real names or other forms of identification of all participants have not been used in documents associated with the research. Pseudonyms are used in this thesis to ensure children’s and teachers’ anonymity.

### 3.8 Triangulation

Triangulation in the social sciences was used at first in the sense that when using different methods to approach a phenomenon and the findings turned out to converge and corroborate each other, then this was an indication that accurate measures were taken. If the findings were not similar, then this was attributed to weaknesses in the strategies applied (Cohen, et.al. 2007).

In an attempt to justify the mixed method approach adopted, the work of Bryman (2006) is recalled, through which 232 social science articles were examined and particularly the rationales for employing a mixed method approach. From the extended review that was followed, Bryman (2006) reported that the scheme included researchers suggesting that “both qualitative and quantitative research have their own strengths and weaknesses so that by combining them allows the researcher to offset their faults and draw on the strengths of both” (p. 106).

For the purpose of the current study a variety of data sources was used to triangulate findings (see above Figure 3.4), including a mixture of qualitative and quantitative methods. For example, interviews, participant observation and collected documents were used in the study in combination with data from pre-test and post-tests. In addition to that, the data depicted perspectives from children, teachers and the researcher; these perspectives were used to confirm assertions made in the study.

For each research question (RQ), data were collected with more than one data collection method. The data collection methods for each research question of the study are shown in Table 3.3. As stated previously the research questions of the study are as follows:

1. What types of decisions do teachers expect secondary education children (11-14 years old) to engage in during different parts of designing and making?

2. What strategies do secondary education children follow in order to make their design choices?
3. What are the difficulties that secondary education children face in their efforts to make decisions in their designs?

4. To what extent can decision-making skills learnt within the area of design and technology be transferred to other activities?

<table>
<thead>
<tr>
<th>RQ1</th>
<th>RQ2</th>
<th>RQ3</th>
<th>RQ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
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<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 3. 3 - Data collection for research questions

3.9 Main Study Sample

The study used a convenience sample of 110 design and technology lower high school children. All participants were aged between 12 and 15 at the beginning of the study. The data collection obtained for the main study and their duration are presented in Table 3.4.

<table>
<thead>
<tr>
<th>Number of Participants</th>
<th>N=15</th>
<th>N=15</th>
<th>N=110</th>
<th>N=110</th>
<th>N=110</th>
<th>N=110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (min)</td>
<td>15-20</td>
<td>15-20</td>
<td>(6X4X45)*</td>
<td>1080 (18h)</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

*(6x6x45) = 6 classes x 4 observations x 45 minutes

Table 3. 4 - Data collection planed for the main study
3.10 Methods of Data Collection

Data collection aims to offer information and evidence relevant to the research questions of the study. For the purpose of the current research, various data collection methods were applied. The data collection methods that were used in this study included interviews with children, direct observations of the children in action while designing; an additional source of information will be children’s log-books, pre-tests and post-tests. All those data aimed to explore how children used their previous experiences in order to take their design decisions. The following sections discuss in detail the purpose and the nature of each data collection method used in the main study.

3.10.1 Interviews

The nature of the enquiry, underpinned by the theoretical background of this study, led to the conclusion that the interview would be an appropriate method (Fontana and Frey, 2000), since “it allows for greater depth than is the case with other methods of data collection” (Cohen and Manion, 1994, p.272). Interviewing is one of the most powerful ways by which we try to understand our fellow human beings. As Kitwood (cited in Cohen and Manion, 1994) explains, “in an interpersonal encounter people are more likely to disclose aspects of themselves, their thoughts, their feelings and values, than they would in a less human situation” (p.282).

To answer the research questions of the current study, it was essential to employ interviews. Interviews are related with all four research questions of the study. Using interviews, some aspects of children’s decision-making could be understood in more depth than they might be through observations (Cohen et al., 2007; Darlington and Scott, 2002). Taylor and Bogdan (1998) suggested that observation is inadequate to provide insights into the participants’ feelings, thoughts and intentions. Interviews under these circumstances are a useful additional source of data.

Furthermore, interviews, when combined with observations, are useful for enlightening observed incidences (Darlington and Scott, 2002), understanding children’s practices and relating them to their conceptions, and thus providing data for the research questions of this study.

The type of interviews could vary from very weakly structured to highly structured depending on the needs of the study. There are usually three types of interviews mentioned in the literature. Robson (1993) distinguishes three kinds of interviews based on their structure: fully structured, semi-structured and unstructured. Silverman (2000) argues that one way of controlling for
reliability in interviewing is to have a fully structured interview, with the same format and sequence of words and questions for each respondent. Scheurich (1995), though, suggests that this neglects the complexity and open-endedness of social interaction. The problem with using a highly structured interview in qualitative research is that rigidly adhering to predetermined questions may not allow the researcher to access participants’ perspectives and understandings of the issues (Merriam, 2001). Instead, the researcher gets reactions to the investigator’s preconceived notions of the ideas (Merriam, 2001). On the other hand, Robson (2002) asserts that a flexible design allows for clarification of meanings. Unstructured interviews are very flexible, but, according to Merriam (2001), they require a skilled researcher to handle the great flexibility demanded by the unstructured interview.

Somewhere in between is semi-structured interviewing, in which a researcher provides minimal guidance and which allows considerable latitude for interviewees. This is reported to be one of the most favoured techniques in qualitative research (Bryman, 2006; Wragg, 1978). In semi-structured interviews, the interviewer has a predetermined questionnaire but is free to modify the wording and order of the question to some extent (Robson, 1993). Explanations are given about the questions, and also particular questions which seem inappropriate with a particular interviewee can be omitted, or additional ones included (Robson, 1993). They also give an interviewer a great deal of flexibility in wording questions and changing their order, since they are more like a conversation than a question-response dialogue.

For the reasons described above, semi-structured interviews with open-ended questions were used in this research study. In this way, both increased reliability and adjustments of the interview to the participants’ characteristics could be achieved. The general purpose of the interviews was to allow freedom to the teachers and children to express their thoughts as fully and as spontaneously (Cohen et al., 2007) as possible and offer flexibility for new issues to emerge. Therefore, semi-structured interviews appeared to be the most suitable method for the study (Phelps et al., 2005).

Two different kinds of semi-structured interviews were employed in this study: pre-observation interviews and post-observation interviews. All of the semi-structured interviews were conducted according to protocols (Appendix 3.4 and Appendix 3.5), ensuring that all the necessary information would be obtained (Gillham, 2000).
The pre-observation interviews (Appendix 3.4) aimed at establishing the starting point of the research, children's abilities to handle design decisions, any particular difficulties they face and children's values included in their decisions. The purpose of the pre-observation interviews was to gather information that would help establish a better understanding of what was happening in the class in relation to the issues that were under investigation. Each interview lasted 15-20 minutes. Examples of questions of the interview were: Do you normally take design decisions (materials, shapes, mechanism etc) during your involvement in the design and technology project? What sources of information do you use (books, teachers, internet, observation etc)? When you have to take a design decision do you think of any factors (criteria) that the decision should satisfy?

The post-observation interviews were aimed at examining in more detail what a child had in their mind whilst working with a specific design project. The emphasis was in design decisions taken for a specific project. The interview included 8 questions, which involved three aspects; children's sources of information (e.g. did you search for further information that helped you take that decision?); the ability to set multiple criteria (e.g. when you took that decision did you think of any factors (criteria) that the decision should satisfy?); children's ability to transfer decision-making skills to other activities (e.g. do you think that the decision-making skills you learned during the design and technology lessons can be used (transferred) to other daily activities). Each interview lasted 20-25 minutes.

All questions posed to the interviewees during the interviews were non-directing, so that their answers would reveal the participants' own views (Cohen et al., 2007). Furthermore, all questions were open-ended, in order to enable the interviewees to show their unique way of looking at a specific phenomenon (Silverman, 2000). Apart from the questions included in the interview schedule, probes and prompts were used to generate more information. Cohen et al. (2007) assert that throughout the interviews, the interviewer must apply suitable probing, encouraging interview subjects to speak further.

In terms of overcoming reluctance, interviews remained fairly conversational and situational. Adler and Adler (2003) have noted that maintaining informality and not rushing respondents are useful strategies. Accordingly, an informal style was adopted and the format of the interview was flexible. In addition, the pre-observation and post-observation interviews were conducted in privacy in school (Cohen et al., 2007).
A digital voice recorder was used to record the interviews. The interviewees were informed that they were being recorded and their consent was obtained. Recording interviews can potentially make the respondents less relaxed, but has the advantage of preserving a more complete record of the interview than would be possible, if taking notes (Smith, 1995, Willig, 2001). Once interviews were completed, a full transcript was prepared. The original language of the interviews was Greek and some selected parts were translated in English for communicating the analysis.

### 3.10.2 Decision-Making Tasks

A design task was prepared for each level and given to children after the pre-observational interview. The task was originally in Greek and had been translated in English for the purpose of the report (example of the English version is shown in Appendix 3.6). Decision-making tasks were developed on the basis that they: had no ‘right’ answer; were linked with some particular technological knowledge from the key area chosen; and contained some information helpful to the decision-making process.

The design projects given to children were different for each year group because of the different curriculum requirements. The Cypriot national curriculum as described in Chapter 4 (pilot study) is more content oriented and the subject is usually conceived in terms of major sub-divisions, such as communications, mechanisms, electronics, structures, and energy. Design decisions have to be taken within a specific domain (for example electronics). More detailed analysis of the Cypriot curriculum can be found in Chapter 4 of this report.

Therefore the design task given to children was based on the curriculum requirements of each class. Despite that similar decisions were expected to be taken by children of all age groups. In class A, children were asked to design and make a simple clock for their room, in class B children were asked to design and make a simple car model and in class C children were asked to design and make an electronic alarm system. Table 3.5 is showing the decisions that were expected from children’s for each year group.
<table>
<thead>
<tr>
<th>Class</th>
<th>Project – Task</th>
<th>Decisions</th>
</tr>
</thead>
</table>
| A       | Simple clock for their wall or Car Model | 1. Shape of the clock  
2. Construction Materials  
e.g. plastic, wood, cardboard |
| B       | Simple car model with mechanisms or game with mechanisms | 1. Type of Mechanism  
e.g. gears or pulleys  
2. Construction Materials  
e.g. plastic, wood, cardboard |
| C       | Electronic alarm system or automatic electronic system | 1. Electronic components for Input, process, output  
2. The purpose of the Alarm system  
e.g. automatic light when is dark or. Fire alarm system etc. |

Table 3. 5 - Design projects for each year group

Children while working with their design tasks were asked to fill a short log-book in which they justified all their design decisions. To make the comparisons easier between different age groups the questions included to the log-books were the same for all three classes A, B and C (the equivalent to year 7, year 8 and year 9 to UK). The following are examples of types of questions to be asked in their log-books:

1. What are your options for that particular decision?
2. For each option given above explain what will happen if you take this option? and why? How important is the consequence? Why?
3. Which option is best in the light of the consequences? What are the most important reasons that make you choose that option?
4. From where did you get your ideas? (sources of information)
5. What are your next steps? How the decision taken will affect your next steps?

Those open type questions do not have right or wrong answers and are giving the chance to children to express their personal values. The questions directly relate to the research questions of the study. Identifying different options and their possible consequences are related to possible strategies that children follow in order to make their design choices (research question 2). Their perception of the importance of each consequence is related with their personal values. The ability to choose an option that is considered to be the best is related to their skills in assessing all available options in the light of their consequences. From this, it is possible to identify difficulties that children face in their efforts to make decisions (research question 3). The
question, requesting children to identify where they get their ideas from, is related to their sources of information and their existing knowledge. Children were also asked to think about their next steps and how the decision taken will affect forthcoming decisions. This question is related to the ability of children to extend their thinking to further issues beyond their designing (research question 4).

3.10.3 Observations

Observation was one of the chosen methods for this research, because it offers the opportunity to gather ‘live’ data from naturally occurring social interactions (Cohen et al., 2007; Darlington and Scott, 2002). In this way, first-hand information is gathered rather than relying on second-hand accounts (Cohen et al., 2007). Thus, it has the potential to yield more authentic data than would otherwise be the case with mediated or inferential methods (Cohen et al., 2007).

Interviews were also conducted, but, according to Robson (2002), what people do may differ from what they say they do. Robson (2002) suggested that interviews only represent teachers’ or children’s views of practice and not their actual practice. It is reasonable to claim the same about questionnaire data.

Observation data, on the other hand, allows the researcher to move beyond self-reported data (Cohen et al., 2007), as observation affords access to events as they occur (Darlington and Scott, 2002). Therefore, observation is the most effective way of finding out what children actually do when they are involved with decision-making activities and, consequently, for answering the second, third and fourth research question of the study.

Like any other method, observation also has weaknesses. First the observer is limited to observable social phenomena, as internal processes of cognition and emotion cannot be observed (Darlington and Scott, 2002). Hence, for this study, observations were combined with interviews and tests for elucidating the children’s reasoning underpinning their practices while taking design decisions.

Secondly, the presence of an observer inevitably impacts on the setting to varying degrees. People who know they are being watched may alter their behaviour in all sorts of ways, both consciously and unconsciously (Longabaugh, 1980). Darlington and Scott (2002) argue that if the researcher is clear about his/her purpose or role, it will be easier for participants to accept the observer and thus they may be less bothered by his/her presence. Consequently, the
observer, in turn, may be less likely to have a negative reactive impact on the setting (Darlington and Scott, 2002). Considering this, the researcher informed the participants of the purpose of the study and his role in the classroom. In addition, the researcher served as the design and technology teacher of the participants and as a result, his presence was natural and like normal design and technology classes.

Furthermore, material obtained through observation is filtered through the observer, who controls what is recorded and, thus, brought to analysis (Darlington and Scott, 2002). The research purpose, the researcher’s conceptual framework, and other biases and assumptions will influence what is noticed and what sense is made of it. Darlington and Scott (2002) emphasized that it is important to build in safeguards to minimize such misinterpretation. The same authors suggested that understanding of the concept being studied is one approach. This can be achieved through prior familiarity with the setting, or through a period of general observation at the commencement of a study. In the case of the current research, the researcher was familiar with the setting as he worked as a teacher at the specific school context.

For classroom observations, the researcher employed a semi-structured observation protocol (Appendix 3.3). It was aimed at guiding the observation and making it more focused (Darlington and Scott, 2002). Ary, Jacobs and Razavieh (2002) contended that the best way to enhance validity is to carefully define the behaviour to be observed. Thus, the observation protocol provided the framework for the observations. The protocol looked at three elements of children’s decision-making, selected from factors identified in the literature review and the pilot study: sources of information, evaluation criteria and type of design decisions.

The sources of information and their frequency of use that the observation protocol recorded included: the teacher, books, internet, existing projects, peers, modelling, trial and error etc. Those factors emerge both from the observations of the pilot study and from the literature review.

The observation protocol also looked at different types of criteria that children used in order to evaluate their choices and base their decisions on. The criteria that were included for the observations were: attractiveness, time limitations, functionality, cost, strength, ergonomics, materials availability etc. Those factors again emerge from the observations of the pilot study and from the literature review.
The third important issue that the observation protocol addressed is the types of design decisions that the children were involved with during their design tasks. The types of design decisions that were included on the protocol were:

- The design decisions were mainly driven by the teacher;
- The design decisions were mainly taken by children;
- The lesson included decision-making opportunities for children;
- The project linked knowledge to meaningful, real-world contexts;
- The activities derive from the project curriculum.

The observation protocol also looked also for other areas that are relevant with children’s decision-making such as: difficulties, strategies used by children, classroom activities and children’s engagement in decision-making activities.

Three classes, with approximately 20 children each, were observed six times each, and the observations were carried out within a period of six weeks. The observations’ aim was to gather as much information as possible about the children’s design decision strategies. The participants were not asked to plan or conduct any special preparation or to make any alterations to their normal routines for the study. The duration of each class period was 45 minutes, as normally.

Another issue under consideration was the recording of the observation data. As part of the study field notes were taken during observation. Many authors argued that carefully prepared recording schedules avoid problems caused when there is a time gap between the act of observation and the recording of the event (Cohen et al., 2007; Patton, 1990). Lofland and Lofland (1995) stressed the necessity of recording as soon as possible after observation. Following their suggestions, the researcher took notes during the observation and wrote them up as full field notes after leaving the class. The attempt was to provide notes that were a faithful recollection of what happened as possible, and clearly distinguished between exact quotations, paraphrasing, and more general recall (Darlington and Scott, 2002; Denzin, 1989). In order to double check the data collected from field notes, two observers were used at the same time. The field notes of the two observers were compared to ensure reliability of data.
3.10.4 Pre-test and Post-test

In addition to interviews and observations, a test was designed and given to children in order to assess their ability to transfer decision-making skills learned in design and technology education to other activities. According to Cohen et al. (2000), tests offer more valid and reliable outcomes than perceptions or opinions that can be obtained from interviews and observations. Another advantage of tests is that comparing scores before and after the program (pre-tests and post-tests) is a strong method for assessing whether outcomes actually changed over time. For the purpose of the pilot study, only a post-test was administrated to children in order to examine the difficulty of understanding the tasks and the time required for the test.

The pilot study pre-tests and post-tests (Appendix 3.7) were based on assessing the impact of the children's decision-making task in other activities. The post-test was administered immediately after the end of the decision-making tasks as part of design and technology classes. The post-test took about 40 minutes. The test consisted of six tasks with varying degree of difficulty and requested the children to choose the “best” possible option taking into account the information given to the tasks.

From the results of the pilot study, it was decided that the test was too long and needed to be shortened for the main study. Therefore, only two tasks were included in the new test. The first was similar to the pre-test (citing an electric power station) questions while the second tasks were related to a more personal decision. The task required children to decide on a specific type of a mobile phone. An example of the questions included to the task is given below:
Maria is looking for a new mobile phone to buy. After a long search she ended up with three possible phones. The following Table contains information about the three phones.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Nokia N81</th>
<th>Samsung G600</th>
<th>Sony Ericsson W910i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>€370</td>
<td>€420</td>
<td>€330</td>
</tr>
<tr>
<td>Weight</td>
<td>140g</td>
<td>105g</td>
<td>86g</td>
</tr>
<tr>
<td>Camera</td>
<td>2 Mega pixels</td>
<td>5 Mega pixels</td>
<td>2 Mega pixels</td>
</tr>
<tr>
<td>Memory</td>
<td>8 GB</td>
<td>2 GB</td>
<td></td>
</tr>
<tr>
<td>3G</td>
<td>Yes</td>
<td>no</td>
<td>Yes</td>
</tr>
<tr>
<td>Talk time</td>
<td>4h</td>
<td>3.5h</td>
<td>9h</td>
</tr>
<tr>
<td>Standby</td>
<td>410h</td>
<td>300h</td>
<td>400h</td>
</tr>
</tbody>
</table>

What would you do if you were in Maria’s place? Explain your thinking.
Is there any additional information that might help you to take (or improve) the decision?
Where will you search to find them?

Explain how you use the criteria listed in the Table? Do you think that all of them are equally important?

Figure 3. 5 - Example of Pre-Test and Post-test

3.11 Limitations and Weaknesses of the Methodology

The use of the pilot study minimised any major limitations of the data collection tools such as interviews and observations. Despite that, the nature of the design tasks set to the children was mainly driven from the Cypriot national curriculum. As a result, a different design project was given to children of different age groups but at least with the same decision making requirements. Therefore, comparisons between each year group need to be drawn very carefully.

Also, the survey and the interview schedule had to go through a process where they had to be approved (in English) before translating them for the participants whose mother tongue is the Greek language. After transcribing the interviews, they had to be translated in English so further
analysis could take place. There was some difficulty in this matter because some expressions when translated did not have the same meaning. This challenge was overcome by summarizing the participant’s response or by using some other English expressions that would help pass the intended message.

3.12 Data Analysis

The analysis of the individual data gathering elements was analysed using standard approaches. As Cohen et al. (2007, p. 461) assert, “there is no one single or correct way to analyse the qualitative data; how one does it should abide by the issue of fitness for the purpose”. Nevertheless, because qualitative data are often overwhelming and unstructured (Creswell, 2007), coding is necessary for reducing the data into meaningful themes (Darlington and Scott, 2002). The coding followed the guidelines given by Miles and Huberman (1994), who distinguished between first- and second-level coding. According to these authors, first-level coding is concerned with attaching labels to groups of words. Second-level, or pattern coding, groups the initial codes into a smaller number of themes or patterns.

Furthermore, for this analysis, the interview and observation protocols were used as a framework to determine the themes. The protocols were segmented and each segment was coded. These codes were related to the research questions and the concepts that emerged from the literature review (Miles and Huberman, 1994). Although the areas of interest had been predefined, the analysis was responsive to additional factors that could emerge in the data (Cohen et al., 2007). After reading through the transcripts, the codes were applied to the data. Later, the codes were combined into broader categories (Creswell, 2007).

The recorded audio files were transcribed into protocols. The field notes during observation, and written works by children, were also used to support the analyses. The protocols were segmented (each sentence was either a simple sentence or an independent clause in a more complex sentence), and then each segment was coded. The coding system for analysing the data was based on the general coding system related to decision-making (Bettman and Park, 1980; Puff, 1982), and it was extended to this study by considering detailed behaviours that appeared in children’s decision-making processes.
3.13 Grounded Theory

The research study mainly used grounded theory as a data analysis approach. Grounded theory analysis is often described as a process of 'discovery' (Hasselgren and Beach, 1997), in the sense that the set of categories or meanings that result from the analysis cannot be known in advance but must emerge from the data through the analysis; a process clearly influenced by the values of the researchers themselves.

Grounded theory differs from many other research methods in that it is explicitly emergent. It does not test a hypothesis or have any pre-set assumptions. It sets out to find what theory accounts for the research situation as it is. In this respect it is like action research: the aim is to understand the research situation and to discover the theory implicit in the data. It is a methodology that has been used to generate theory in areas where there is little already known (Goulding, 1998).

Its usefulness is also recognised where there is an apparent lack of integrated theory in the literature (Goulding, 2002). In the case of the current study there is a significant gap in the literature as to how children develop decision-making skills and hence such an approach will be relevant. Grounded theory “adapts well to capturing the complexities of the context in which the action unfolds” (Locke, 2001, p.95). Therefore, grounded theory can be of direct relevance for practitioners in that it analyses a substantive topic and can help to articulate and explain basic social processes, such as decision-making (Jones, 2002).

3.13.1 Grounded Theory Stages of Analysis

Grounded theory analysis follows the basic coding sequence (open→axial→selective) iteratively between primary data and the emerging theoretical framework. It is important that the codes and categories that label emergent concepts are derived directly from the data. Authenticity is enhanced by the use of in vivo codes which are labels named from the actual verbatim words found in the data (Strauss and Corbin, 1998 p.105). The different phases of Strauss and Corbin’s (1998) coding sequence could be illustrated in Figure 3.6 as follows:
3.13.2 Pilot Study Coding

According to grounded theory, from the data collected the key points are marked with a series of codes, which are extracted from the text, identifying anchors that allow the key points of the data to be gathered. The codes are grouped into similar concepts, in order to make them more workable, collections of codes of similar content that allows the data to be grouped. From these concepts, categories are formed, which are the basis for the creation of a theory, broad groups of similar concepts that are used to generate a theory. This provides an alternative strategy to the traditional model of qualitative research, where the researcher chooses a theoretical framework, and only then applies this model to the studied phenomenon (Allen, 2003). Table 3.6 represents the coding stages having been used for the analysis of the pilot study.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codes</td>
<td>Identifying anchors that allow the key points of the data to be gathered</td>
</tr>
<tr>
<td>Concepts</td>
<td>Collections of codes of similar content that allows the data to be grouped</td>
</tr>
<tr>
<td>Categories</td>
<td>Broad groups of similar concepts that are used to generate a theory</td>
</tr>
<tr>
<td>Theory</td>
<td>A collection of explanations that explain the subject of the research</td>
</tr>
</tbody>
</table>

Table 3.6 - Grounded theory analysis stages

**Summary**

The purpose of the research was to identify factors that affect children’s decision making strategies. The theoretical framework emerged from a literature review which revealed the complexity of the processes involved. Direct observations, interviews, log-books, pre-tests and post-tests formed the data of the research and from which useful information is emerging on how children handle decision-making in design and technology education. Next sections will describe the analysis of the results of the pilot and the main study.
Chapter 4: Pilot Study Results

Overview: This Chapter is presenting the data analysis methods used with emphasis on grounded theory analysis. The emergent outcomes from the pilot study as analysed are also presented.

4.1 The Pilot Study

A pilot study is a small experiment designed to test the data collection methods and gather information prior to a larger study, in order to improve the research quality and efficiency. A pilot study can reveal deficiencies in the design of a proposed experiment or procedure and these can then be addressed before time and resources are expended on large scale studies. A good research strategy requires careful planning and a pilot study is often part of this strategy (Cohen, Manion and Morrison, 2007).

A pilot study is normally small in comparison with the main experiment and therefore can provide only limited information on the sources and magnitude of variation of response measures. The pilot study for the current research employed data collected from teachers’ interviews, comparisons of curriculum materials from Cyprus, England and Iceland, interviews with children, children’s log-books, observations of children while designing and a test with decision-making tasks (for more detailed descriptions please see in Section 3.6.1).

4.2 Data Analysis Methods

The pilot study, as a starting point of the research, did not have any pre-set ideas about the application of decision-making skills in design and technology education. The intention of this study was mainly to get initial ideas on how teachers and children handle decision-making activities in their teaching and learning. As a result, mainly grounded theory techniques were used to analyse the data collected from the pilot. Grounded theory refers to theory that is developed inductively from a corpus of data study (Glaser 1994). This means that the resulting theory is based on the responses of the research participants and not on any pre-set ideas. The reasons for choosing grounded theory as an analysis approach were presented earlier in Chapter 3.
4.3 The Results of the Pilot Study

The pilot study was divided in two phases. The first phase was the investigation of teachers’ views on how children acquire decision-making capabilities in design and technology education and at the same time the review of national curricula in Cyprus, England and Iceland (more details can be found in Section 3.6.1). The second phase was dealing with the children’s point of view and included a specific design task while data from children’s log-books, observations, pre-tests and interviews were collected (for more detailed description see Section 3.6.1). The results from the two phases are presented separately and possible interrelations, similarities or differences between the two phases and between the different data collection methods are discussed.

4.3.1 Interviews with Teachers from Cyprus, England and Iceland

This section will present teachers’ views about the various strategies that children followed in design and technology classes. For a more detailed explanation about the reasons that these three countries participated in this part of the research see Section 3.6.1.

Interviews were tape recorded and transcribed verbatim, making the transcripts the focus of the analysis. Teachers’ ideas about children’s decision-making capabilities were analysed and categorised. As explained in Figure 3.6 specific codes were selected that represent a certain concept of the research. The following is an example (Table 4.1) of the transformations of codes into concepts that were delivered for the interviews with teachers of the pilot study.
### Table 4.1 - Example of interview coding

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from teachers interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Types of decisions (appearance, materials)</td>
<td>Researcher: Can you give me an example of decision-making you expect children to engage in during different parts of designing and making? Teacher 1: Children are expected to design the item set in the brief. For example in Year 9 the children design a set of jewellery in a group of three. They must design the jewellery for a given audience and to a given theme. They must decide what the item will look like, how they will make it and what materials they will use from the selection they are given (1). They must design different pieces of jewellery and decide which piece to develop and model before making (1). To help that decision the children are expected to talk to their group members (2) as well as me (3).</td>
</tr>
<tr>
<td>2. Sources of information-peers</td>
<td></td>
</tr>
<tr>
<td>3. Sources of information-teacher</td>
<td></td>
</tr>
<tr>
<td>4. Age – more expectations as they grow up</td>
<td>Researcher: Do the design decisions become more complex as the children grow older? Teacher 1: Yes, the children are expected to take more control of their projects especially in Year 11 when doing their GCSE project. (4) They are given a brief but they must come up with their own design, chose their own materials and think about the processes that they will use (1). They are given guidance but more freedom than in Key Stage 3.</td>
</tr>
<tr>
<td>5. Difficulties to cover NC</td>
<td></td>
</tr>
<tr>
<td>6. Age – give them more choices as they grow up</td>
<td>Researcher: What do you think about the guidelines of the national curriculum in terms of design decision making? Does the national curriculum include opportunities for design decisions? Teacher 1: The NC applies to KS3 as the KS4 children follow a specification set by the exam boards. There is a lot to cover in the NC and it is difficult to cover everything (5). We expect the children to progress year on year and become better at core skills (such as specification writing, sketching and designing) so that they are able to gain higher NC levels. The way in which we write our schemes of work allow the children to make more decisions in their projects and to cover skills in more detail as they grow older (6).</td>
</tr>
</tbody>
</table>

Similar concepts that emerged from the pilot study were grouped in broad categories. The categories that emerged were connected in order to design a theoretical framework that explains the factors that are involved in children’s decision-making. An example of the transformation of concepts into categories is presented in Table 4.2.
Chapter 4: Pilot Study Results

The main outcomes of the interview with teachers which emerged from the analysis of the pilot study are presented in the following sections. For each issue that is related with the research certain tables will summarise the codes and the concepts from the data.

From the analysis of the results it can be observed that during the first stages of secondary school (age 11-12) teachers set quite rigid tasks to children, giving to them very few decision-making opportunities. Teachers believed that young children (age 11-12) needed to work with very structured tasks in order to gain basic designing skills. As they were progressing they were given more complex tasks and more choices, and consequently more decision-making opportunities. This outcome was identified both with teachers from Cyprus (N=4), England (N=4) and Iceland (N=4). Table 4.3 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Age – more expectations as they grow up</td>
<td>1. Teachers have more expectations in decision-making from children as they grow up</td>
</tr>
<tr>
<td>7. Age – give them more choices as they grow up</td>
<td></td>
</tr>
<tr>
<td>5. Types of decisions – (materials, processes)</td>
<td>2. Teachers expect children to take decisions on issues such as materials, appearance, processes.</td>
</tr>
<tr>
<td>1. Types of decisions (appearance, materials)</td>
<td></td>
</tr>
<tr>
<td>2. Sources of information-peers</td>
<td>3. Teachers identify as sources of information for children their peers and their teachers.</td>
</tr>
<tr>
<td>3. Sources of information-teacher</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. 2 - Example of the transformation of concepts into categories

Table 4. 3 - Type of tasks given to children’s by teachers
Teachers from Cyprus (N=3 out of 4), England (N=3 out of 4) and Iceland (N=2 out of 4) expressed the belief that the curricula in all countries include decision-making opportunities, but in practice it is difficult to apply those decision-making opportunities with children owing to many limitations (time, resources and children’s abilities). Table 4.4 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
</table>
| T.I.3. NC in all countries includes decision-making opportunities, but in practice it is difficult to apply those decision-making opportunities. | Cypriot teacher 2: “The guidelines of the national curriculum are giving many opportunities to teachers to set decision-making tasks. Despite that in practice, time limitations minimize those opportunities”  
English teacher 1: “The curriculum does allow opportunities for design decisions but these may be limited by resources available or what is practical in a lesson”  
Icelandic teacher 4: “The curriculum is too complicated and asks for too much of the teacher as the time is too little” |

Table 4. 4 -Teachers’ difficulties in applying the requirements of curricula

One important element before any decision-making was the ability to seek information in order to improve their knowledge to support the design decision. Teachers mentioned various sources of information that children went through in order to support their decisions. Table 4.5 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
</table>
| T.I.4. Children don’t look for sources of information to support their design decisions | Cypriot Teacher:  
e.g. “I think that children are not using a range of information sources for their design decisions. They mainly use their textbooks, but very rarely will look for additional books”.  
English Teacher:  
e.g. “Some (children) are able to take the information they are given and produce work independently, whereas others struggle with this and need a lot more focused help”  
Icelandic Teacher:  
e.g. “Children don’t really search for information for their projects, when they do that they are using the internet as the main source of information, but there is a lack of online teaching material” |

Table 4. 5 -Teachers’ ideas on how children search for information for their design work
The main sources that children used, according to their teachers’ points of view as identified form the pilot study, are presented in Table 4.6. The Table presents the sources of information identified from teachers of each country separately.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
</table>
| T.I. 5.1 Teachers’ views about sources of information for children in Cyprus | According Cypriot Teachers:  
- Guidance of their teachers  
- Projects from past year’s children,  
- Internet resources  
- Existing knowledge (built from previous projects and skills exercises) |
| T.I. 5.2 Teachers’ views about sources of information for children in England | According English Teachers:  
- Guidance of their teachers  
- Internet resources  
- Projects from past year’s children,  
- Modelling - product analysis  
- Existing knowledge (built from previous projects and skills exercises) |
| T.I. 5.3 Teachers’ views about sources of information for children in Iceland | According Icelandic Teachers:  
- Internet resources  
- Influence within their class  
- Guidance of their teachers  
- Projects from past year’s children |

Table 4.6 - Type and importance of sources of information that children use

Teachers from all three countries (N=10 out of 12) expressed the belief that the majority of books that are in use in design and technology classes do not include many direct decision-making opportunities. Table 4.7 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.I.6. Books do not include decision-making opportunities for children</td>
<td>Cypriot teacher: “The textbooks that are used for secondary education don't include many opportunities for decision-making. Their main aim is to serve as textbooks that children will have the opportunity to use and gain knowledge and information that will be important and helpful in their decision-making”</td>
</tr>
</tbody>
</table>
| T.I.7. Difficulty to collect information from the book | English teacher “Many of the books that we use for design and technology teaching are extremely focussed on delivering information”  
Icelandic teacher “Most of the times we are using English design and technology books but the children face difficulties in collecting information autonomously from the books” |

Table 4.7 - The effect of books in children’s decision-making
Teachers from all three countries (N=9 out of 12) expressed the belief that children have many difficulties in setting appropriate criteria in order to evaluate their available options. For example, when children are asked to evaluate possible options it is very difficult for them to set any criteria further than attractiveness. Table 4.8 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.I.8. Difficulty to set criteria</td>
<td>Cypriot teacher: “I think that children most of the time don’t set certain criteria to evaluate their design decisions”.</td>
</tr>
<tr>
<td>T.I.9. Set criteria such as aesthetics and style</td>
<td>English teacher: “I find that the younger children identify obvious attributes related to the aesthetics, style and function of the product, however as they get older they can also bring in more subtle criteria, i.e. ergonomics. The main area that is affected though is the ability to justify and explain their opinions and reasons for including criteria for evaluation. The younger the children the harder they find it to include the detail and justification required”.</td>
</tr>
<tr>
<td>T.I.10. The ability to set criteria improves with age</td>
<td>Icelandic teacher: “Children use the internet to help them specify criteria, many establish their criteria by using the internet and look inside of themselves to find want they want to make”.</td>
</tr>
<tr>
<td>T.I.11. Sources of information –internet</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8 - The ability to set appropriate assessment criteria for their decisions

During interviews teachers from the three countries identified some difficulties that children face in their effort to make rational design decisions. Table 4.9 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.I.12. No formal instruction on how to make decisions</td>
<td>Cypriot teacher: “The main difficulty is that children are asked to make a decision without giving them any formal instruction on decision-making techniques”.</td>
</tr>
<tr>
<td>T.I.13. Don’t want to spend time designing</td>
<td>English teacher: “The main problem we have is that children do not want to spend time designing their product and researching possible solutions. Most would rather rush straight into making, and we have to stop them and give them structured design tasks to follow”.</td>
</tr>
<tr>
<td>T.I.14. No motivation to think about decisions</td>
<td>Icelandic teacher: “Children don’t have the motivation to think in-depth about their design decisions, and as a result they decide without exploring all the available options or the information needed”.</td>
</tr>
</tbody>
</table>

Table 4.9 - Lack of motivation faced by children according to teacher views
Teachers from all countries (N=12 out of 12) seemed to feel unsure as to whether decision-making skills learned within design and technology classes are transferable to other subjects or other daily activities (such as personal purchasing). Table 4.10 gives some typical examples of teachers’ responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Teachers Codes</th>
</tr>
</thead>
</table>
| T.I. 15. Teachers don’t know if children can transfer skills | Cypriot teacher: “I am not sure about the ability to transfer skills, but I believe that this can be the case only for few children. As they grow older maybe children are more able to transfer their skills to everyday activities”.

English teacher: “I am not sure, I would hope so, as we do as we gain more experience, but I don’t think there is a direct link to skills learnt in class”.

Icelandic teacher: “I don’t know, this has to be research in more depth mainly by the academic researchers”.

Table 4. 10 -Teachers’ views on the ability of children to transfer the skills from design and technology to other everyday activities.

4.3.2 Review and Comparison of Design and Technology in the Curricula of Cyprus, England and Iceland

The review and the comparison of the national curricula of the three countries were made with emphasis on the decision-making opportunities that were included in their design and technology curricula. Following is an example (Table 4.11) from the English National Strategy (2004), codes that include decision-making activities were selected and categorised for further analysis.
Table 4.11 – Example of analysis of National Curriculum

<table>
<thead>
<tr>
<th>Decision Opportunities</th>
<th>Year 7 (12 years old)</th>
<th>Year 8 (13 years old)</th>
<th>Year 9 (14 years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children seek out information to help their design decisions.</strong></td>
<td>Use a range of information sources, mainly provided by the teacher</td>
<td>Draw upon a wide range of information sources including those not provided by the teacher</td>
<td>Combine ideas from a variety of sources</td>
</tr>
<tr>
<td><strong>Children select appropriate techniques to evaluate how their products would perform when used and modify their products in the light of the evaluation to improve their performance</strong></td>
<td>Use a range of strategies to explore and experiment with ideas before making judgements</td>
<td>Try fresh or alternative approaches when developing ideas and overcoming new problems and challenges</td>
<td>Continually think visually, spatially and analytically when developing and evaluating ideas</td>
</tr>
<tr>
<td><strong>Children make realistic plans for achieving their aims. They think ahead about the order of their work, choosing appropriate tools, equipment, materials, components and techniques</strong></td>
<td>Identify that products are made from a variety of different materials</td>
<td>Identify the different materials and components and suggest why they have been used</td>
<td>Make alternative design proposals regarding the choice of material</td>
</tr>
</tbody>
</table>

For the comparisons to make more sense the decision-making capabilities that were required for each age-group are presented separately in the following Tables. Some representative objectives for each level were selected from each country and presented in the following Tables (Tables 4.12 to Table 4.14) in order to indicate the different decision-making requirements of each country.
<table>
<thead>
<tr>
<th>12-13 years old</th>
<th>13-14 years old</th>
<th>14-15 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyse simple products and describe possible design decisions taken by manufacturers ((1))</td>
<td>Analyse existing mechanical products and describe possible design decisions taken by manufacturers (1)</td>
<td>Analyse existing electric products and describe possible design decisions taken from manufacturers (1)</td>
</tr>
<tr>
<td>Decide the purpose of simple constructions (2) that introduce children to basic materials</td>
<td>Decide and describe a simple technological problem (3) that is possible to be solved with simple mechanisms (gears, pulleys, cams, crank and slider etc.)</td>
<td>Decide and describe a simple technological problem (3) that is possible to be solved with electronics</td>
</tr>
<tr>
<td>Children should search or finformation (4) and decide upon the appropriate shape, materials, size, strength, use, decoration (5) etc. of their project</td>
<td>Decide the appropriate appearance, mechanism and decoration (5) for moving picture with levers and linkages</td>
<td>Choose the appropriate components for the input, process, and output of an electronic system (5) Inputs: LDR, thermistor, moisture sensor, switches Process: transistors, Darlington pair, thyristor. Outputs: light bulb, buzzer, motor, loudspeaker, LEDs</td>
</tr>
<tr>
<td>Evaluate and judge if the artefact you made satisfies the specification of the project.</td>
<td>Evaluate and judge if the mechanical system you designed satisfies the specification of the project.</td>
<td>Evaluate and judge if the electric system you designed satisfies the specification of the project.</td>
</tr>
</tbody>
</table>

**Concepts**

C.C.1 Children identify design decisions taken by manufacturers for existing products
C.C.2. Children decide the reason for making a certain design.
C.C.3 Children choose their own project within a special topic (eg. mechanisms or electronics).
C.C.4 Children search for information relevant to the decision they have to take.
C.C.5 Children take decisions upon the appropriate appearance, materials, mechanisms, decoration, electrical components etc.

Note: C.C. means Cypriot Curriculum

Table 4. 12 - Objectives from the Cypriot National Curriculum (2006)
<table>
<thead>
<tr>
<th>11-12 years old</th>
<th>12-13 years old</th>
<th>13-14 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sharing decisions with the teacher</strong> (6) and others</td>
<td>Working independently on a task determined by the teacher</td>
<td>Working independently on a chosen task</td>
</tr>
<tr>
<td>Evaluating strengths and weaknesses-how well does it work?</td>
<td>Explain the choices and decisions made in designed and manufactured products (7)</td>
<td>Prioritizing and reconciling decisions on materials, time and production (8)</td>
</tr>
<tr>
<td>Find and select information (9), which informs and clarifies thinking about the task</td>
<td>Discuss, debate, question and challenge information and the nature of the task itself</td>
<td>Select information sources (9), gathering and sorting data that will help with decisions about the design</td>
</tr>
<tr>
<td>Explore and experiment with and then select appropriate materials and processes (8)</td>
<td>Find out what materials and components are available (8) and use technical information to decide on their suitability for the task</td>
<td>Make and justify decisions regarding the choice of materials (10) and manufacturing processes and use them to draw up a manufacturing specification</td>
</tr>
<tr>
<td></td>
<td>Justify decisions made (10) in the selection of materials and methods of making</td>
<td>Identify any design weaknesses in the choice of materials and manufacturing processes</td>
</tr>
</tbody>
</table>

**Concepts**

E.C. 1. Children share their decisions with the teacher  
E.C.2. Children explain design decisions taken by manufacturers for existing products  
E.C.3. Children take decisions upon materials, time and production  
E.C.4. Children search for information relevant to the decision they have to take  
E.C.5. Children justify decisions regarding the choice of materials  

Note: E.C. means English Curriculum

Table 4. 13 - Objectives from the English National Curriculum (2004)
<table>
<thead>
<tr>
<th>12-13 years old</th>
<th>13-14 years old</th>
<th>14-15 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be able to work independently through a design process</td>
<td>Think about the value of artistic outlook in their design when they make their choices (11)</td>
<td>Take ergonomic issues into account when they make their design decisions (11)</td>
</tr>
<tr>
<td>Identify needs and problems in their environment before taking their design decision</td>
<td>Define a need and establish a main concept and develop it by focusing on its functionality and usefulness in the society</td>
<td>Work though a design process based on own specific concept. They should be able to discuss their work with their peers when making their design decisions (12)</td>
</tr>
<tr>
<td>Base their design decision on solving a need and design an artifact to show the outcome</td>
<td>Identify needs and problems in society though own observation before choosing their solution</td>
<td>Show initiative and be autonomous in their design work. They also have to be able to seek for and apply knowledge by using ICT.</td>
</tr>
<tr>
<td>Make their own design drawings in order to come to a decisions about possible solutions (13)</td>
<td>Show their chosen solution in a form of an artifact made from solid material</td>
<td>Take sustainability into account in their design decisions (11)</td>
</tr>
<tr>
<td>Base their design choices on technical solutions and focus on the artifacts functionality (14)</td>
<td>Make design drawing of his/her solutions when making their choices</td>
<td>Evaluate their design and be able to argue about its quality</td>
</tr>
</tbody>
</table>

**Concepts**
- I.C.1. Children consider factors such as appearance, ergonomics and sustainability in their design decisions
- I.C.2. Children discuss their decisions with peers
- I.C.3. Children design alternative solutions
- I.C.4. Children based their choices on technical solutions

Note: I.C. means Icelandic Curriculum

Table 4. 14 - Objectives from the Icelandic National Curriculum (2004)
4.3.3 Results from the Design Task Set to Children in the Pilot Study

The following sections present the outcomes of the data collected from the pilot study during children’s involvement with the design task. More detailed description on the requirements of the design task that was given to children can be found in Section 3.6.1.

4.3.4 Children’s Interviews

The children’s interviews were analysed using the same coding system that was used for the teachers’ interviews. During the interviews, children expressed their beliefs about their experiences with design decisions in design and technology classes. They also responded to decision-making tasks in relation to their technology projects. The main outcomes from the interviews are presented below:

Most children based their design decisions mainly on their prior experiences (N=12 out of 15) from the subject. They tended to choose materials and processes that they used in their previous projects, using their empirical knowledge, as developed through the subject. Table 4.15 gives some typical examples of children’s responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children interviews</th>
</tr>
</thead>
</table>
| C.I.1. Children use their prior experience to select possible materials | Child 4: “I usually make use of materials that I applied in my previous projects and turned out to be good choices”.
| | Child 2: “I always consider materials or mechanisms that I used in my previous projects”.
| | Child 7: “Most of the times I use some basic materials that I know their properties from my previous work, so I am more confident that I will have good outcome”.

Table 4. 15 - Children’s views on the use of their prior experiences in their next decisions

Peers seemed to play an important role in children’s decisions, both in their technology projects and in their personal decisions as well (e.g. purchase of mobile phones). They discussed their ideas with their peers and sometimes asked them to guide them about their decisions, or they imitated their peers’ choices on similar decisions (N=11 out of 15). Table 4.16 gives some typical examples of children’s responses.
Chapter 4: Pilot Study Results

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children interviews</th>
</tr>
</thead>
</table>
| C.I. 2. Peers influences children’s own decisions | Child 1: “I always ask my friends for their own ideas for many of my decisions in my life and sometimes in my technology projects as well”.  
   Child 6: “When I am not sure what or how to do something I see what my friends are doing and follow them sometimes”.  
   Child 9: “Well, even if someone doesn’t notice it the influence from his friends is very big, is important that what you’re doing is accepted from your own friends”. |

Table 4.16 - Peers’ influences in children’s decision-making in design and technology

From the interviews, it emerged that teachers seem to be very important sources of information for children. When children are not certain about their next steps they tend to ask their teacher to suggest the best possible solution. From the results it can be seen that the importance of teachers as a source of information is more evident in year 7 (age 12-13) (N=6 out of 8) and less important in year 8 (age 13-14) (N=4 out of 7). Table 4.17 gives some typical examples of children’s responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children interviews</th>
</tr>
</thead>
</table>
| C.I. 3.1 Sources of information: teacher, internet, books, peers, existing projects | Year 7 (age 12-13)  
   Child 1: “When I am not sure about the best choice for my project I ask my teacher to help me”.  
   Child 3: “My teacher is who I will ask to give me the information that I need. Sometimes I search to the internet or my books”  
   Child 6: “I do use a number of sources of information, the internet, my teacher, asking my friends, some other ideas used by other children etc”. |
| C.I.3.2 Sources of information: teachers, books, existing projects, trial and error, internet | Year 8 (age 13-14)  
   Child 8: “Most of the times I use information within the class, asking my teacher, trying to find ideas from my book or existing artifacts made by other children”  
   Child 11: “Teachers, friends, a number of web-pages, my own books and sometimes I just try thinking and then take my decision based in the outcome”.  
   Child 14: “First I will look and search through different web-pages in order to find information. Most of the times I will look for more than one web-page and decide if the information I get is correct” |

Table 4.17 - Children’s sources of information

The interviews revealed that when dealing with design decisions, children have difficulties setting appropriate criteria to evaluate their possible options. Table 4.18 gives some typical examples of children’s responses.
Chapter 4: Pilot Study Results

C.I.4. Children don’t use evaluation criteria for their design projects

Child 6: “Because of the time limitation I took the design decisions without thinking of any possible criteria that should be accomplished. I have in my mind some guidelines and I use my past experience to take the decision”.

Child 2: “Always it is important to make something that looks nice, and this is my main criterion basically”.

C.I.5. Children refer to specific criteria in their personal decisions.

Child 13: “When I want to buy something for myself I always decide about the important aspects that I want it to have, the appearance and the cost are always important”.

Child 9: “When I chose my personal mobile phone I had in mind specific features that the phone must have, like good memory, camera, Bluetooth etc.”

Table 4.18 - Difficulties in setting appropriate assessment criteria

Children expressed the belief that they do not feel that they can transfer their abilities from school to other areas of life, such as personal purchasing. Only some children (N=2 out of 7) in year 8 (age 14) believed that school teaching can help them take personal decisions as well.

Table 4.19 gives some typical examples of children’s responses.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.I.6. Children do not recognise any transfer of skills</td>
<td>Year 7 (age 12-13)</td>
</tr>
</tbody>
</table>
| | Child 4: “I think that school is something different from personal life. What we are taught in school cannot be directly applied in our personal decisions”.
| | Child 2: “When I have to take a decisions in my personal life I don’t make use any of the information gained in classes”.
| | Child 7: “Not really, in my everyday decisions I don’t think that I am using any of the skills gained in the class”.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.I.7. Some children in year 8 refer to some transfer of skills</td>
<td>Year 8 (age 13-14)</td>
</tr>
</tbody>
</table>
| | Child 15: “When I was in a shop to choose a pair of shoes, I was between two pairs and I had to choose one, I thought in a similar way that we are doing in our classes in design and technology when we choose of the most appropriate materials”.
| | Child 12: “Maybe sometimes I use the ideas and skills gained from the subject (design and technology) in my daily decisions, but because most of them are quick decisions I don’t realize it”.

Table 4.19 - Children’s ideas on their ability to transfer their skills from design and technology to other areas of life
4.3.5 Children’s Log-books

Children kept log-books during the project in which they justified their design decisions. In their log-books children expressed their thoughts before taking a decision, the reasons that made them take a specific decision, their prior-knowledge, the information they used and their next steps etc. A sample from the children’s log-books is shown in appendix 3.3.

Children’s log-books were analysed using the same procedures as for interviews described in the previous sections. Following in Table 4.20 is an example of one child’s log-book and how the concepts emerged from the children’s codes.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children log-books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from their personal interests</td>
<td>From where did you get your ideas?</td>
</tr>
<tr>
<td></td>
<td>Children: “Football is my favourite sport and I decided to design a moving picture with this topic”</td>
</tr>
<tr>
<td>Relate an existing decision with forthcoming decisions</td>
<td>What are your next steps? For example, the moving parts of the picture will have an effect to the appropriate mechanism that will be used?</td>
</tr>
<tr>
<td></td>
<td>Children: “I think that my idea will affect the type of mechanism that I will use because I want a certain direction of movement and therefore it will affect the type of mechanism”</td>
</tr>
</tbody>
</table>

Table 4.20 - Example of the coding of children’s log-books

When they had to decide about the theme of their design project, the majority of children chose topics related to their everyday activities or hobbies, for example sports logos (mainly boys) and love hearts (mainly girls). Figure 4.1 shows some typical examples of boys’ and girls’ projects.
Children explained the reasons why they chose a particular theme for their projects in their log-books. Table 4.21 shows some typical reasons mentioned by children for choosing the topic of their project.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children log-books</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.B.1. Children select ideas from their everyday activities and their interests</td>
<td>Child 7: “I chose this shape because it is the logo of my football team”</td>
</tr>
<tr>
<td></td>
<td>Child 16: “I love football and I remember a beautiful goal of my team and I decided to make this idea in my project”</td>
</tr>
<tr>
<td></td>
<td>Child 21: “I got my idea from a recent movie that I watched, in where many sharks were attacking people on a small island. My friends helped me to develop my idea further”</td>
</tr>
<tr>
<td></td>
<td>Child 43: “I decided to choose this idea because recently I visited my dentist, and I decided to something similar to that”</td>
</tr>
</tbody>
</table>

Table 4. 21 – Children’s reasons for choosing a certain topic from log-books
During the design task children mentioned in their logbooks a number of sources of information that they used in order to acquire the relevant knowledge for their design decisions. Some typical responses of children are shown in Table 4.22:

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children log-books</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.B.2. Sources of information: existing projects, teachers, peers, materials properties</td>
<td>Child 2: “Mainly I chose this idea based on other constructions that I saw in the workshop, so that I will not face any difficulties”.</td>
</tr>
<tr>
<td></td>
<td>Child 12: “I chose that material because I remember the teacher mentioning that it is easier to shape”.</td>
</tr>
<tr>
<td></td>
<td>Child 27: “I chose this material because the other option I had was a material that was very brittle and because the shape of my construction was a bit complicated, I decided not to use it”.</td>
</tr>
<tr>
<td></td>
<td>Child 48: “Because my friend was already deciding about her idea, I thought to make something similar so we can use them together”.</td>
</tr>
</tbody>
</table>

Table 4.22 - Sources of information mentioned by children in their log-books

Table 4.23 shows the frequency of the main sources of information that children used during their design project as identified from children log-books. The sources are listed in hierarchical order according to their frequencies.

<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Year 7 (age 12-13) (N=30)</th>
<th>Year 8 (age 13-14) (N=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>N=13</td>
<td>N=8</td>
</tr>
<tr>
<td>Peers</td>
<td>N=7</td>
<td>N=6</td>
</tr>
<tr>
<td>Existing Projects</td>
<td>N=5</td>
<td>N=4</td>
</tr>
<tr>
<td>Internet</td>
<td>N=3</td>
<td>N=5</td>
</tr>
<tr>
<td>Books</td>
<td>N=2</td>
<td>N=3</td>
</tr>
<tr>
<td>Trials</td>
<td>-</td>
<td>N=3</td>
</tr>
</tbody>
</table>

Table 4.23 – Children’s sources of information from log-books

In their logbooks children were asked to describe their thoughts on whether their current design decisions could affect their forthcoming decisions on their project. For instance, children were asked to decide if the desirable type of movement might affect the type of mechanism that they
would use. Younger children (age 12-13) believed that one decision would not affect the decisions that would follow (N=27 out of 30). Older children (year 13-14) believed that one design decision could possibly affect other decisions that follow (N=11 out of 29). Some typical responses of children are shown in Table 4.24.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Codes from children log-books</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.B.4. Most children believe decisions already taken will not affect next decisions</td>
<td>Child 12: “No it will not affect my next decisions” (3)</td>
</tr>
<tr>
<td>L.B.5. Some children believe decisions already taken will affect next decisions</td>
<td>Child 21: “I think that my previous decisions will not affect in any way any future decisions in this project” (3)</td>
</tr>
<tr>
<td></td>
<td>Child 38: “Yes, the decisions that I took up to now, will play a significant role on my next steps and forthcoming decisions” (4)</td>
</tr>
<tr>
<td></td>
<td>Child 53: “I think that my idea will affect the type of mechanism that I will use because I want a certain direction of movement and therefore will affect the type of mechanism” (4)</td>
</tr>
</tbody>
</table>

Table 4.24 – Children’s codes in relation to the possibility that a decision taken in one area will affect the decision taken in the forthcoming decisions of the project

The degree to which children of different age groups believed that any of the decisions that they had already taken for their project would possibly affect other forthcoming decisions or not are presented in Table 4.25.

<table>
<thead>
<tr>
<th>Decision</th>
<th>Year 7 (age 12-13) N=30</th>
<th>Year 8 (age 13-14) N=29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will affect</td>
<td>10% (N=3)</td>
<td>37.9% (N=11)</td>
</tr>
<tr>
<td>Will not affect</td>
<td>90% (N=27)</td>
<td>62.1% (N=18)</td>
</tr>
</tbody>
</table>

Table 4.25 - Children’s beliefs about how one design decision might affect the next decisions in the same project.

4.3.6 Observations

Two teachers were used as observers in the pilot study. Because research was in the initial stages, observers didn’t use any structured observation protocol. They were asked to note down anything that they were observed that was related to children's decision-making strategies. Table 4.26 presents a small sample of observation and explanations about the analysis used.
Observation by teacher 1 | Observation No: 2nd | Date: 27/10/2007 | Class: A
---|---|---|---

**Observation Notes**

Children go straight for the making part, without first properly designing (1) their projects. Teachers’ asked from children to search information relevant to their decision, very few children collected information for their project before coming to the workshop (2).

Children ask their teacher for information (3) they don’t know

Children’s drawings are similar to their peers (4)

Some children are making their projects very similar to existing projects available in the workshop (5)

Teacher asks children to write the criteria for each decision they will take, children seem to think mainly the appearance (6)

**Concepts**

C.O.1. Lack of motivation for the designing part of the project
C.O.2. Children don’t search for relevant information outside class
C.O.3. Children use their teacher as a source of information
C.O.4. Children use their peers as a source of information
C.O.5. Children use previous years’ projects as a source of information
C.O.6. Difficulty to set evaluation criteria

Note: C.O. means Children’s Observations

Table 4.26 - Sample of the pilot study observation

The observations showed that most children rarely searched for relevant information outside the classroom before taking their design decisions. Most of the children, although they were asked by their teacher to do their own research before taking any design decision for their project, ended up searching for relevant information within the classroom environment. Some sources of information observed to be used were teachers, previous year’s projects, peers etc. Table 4.27 shows the frequency of some sources of information that were observed during the pilot study.
Concepts
C.O.7. Children’s sources of information includes, teachers peers, existing projects, internet, books, trials

Table 4.27 – Children's sources of information observed during the pilot study.

4.3.7 Pre-test Given to Children
The purpose of the pre-test was to investigate how children responded to decision-making tasks outside the area of design and technology. The test consisted of 4 individual tasks that required children to take and explain a decision among a number of alternatives (Appendix 4.1).

Task 1 required from children to decide the best place to buy land in order to build a house on it, from one of the three locations with the characteristics shown in Table 4.28.

<table>
<thead>
<tr>
<th>Location A</th>
<th>Location B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£40 000</td>
</tr>
<tr>
<td>Time require for travelling to his job</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>

Table 4.28 - Task 1 information given to children

Children’s responses given for task 1 were grouped according to the decisions that the children reached. The frequencies of their responses are presented in Table 4.29.
Chapter 4: Pilot Study Results

### Location chosen

<table>
<thead>
<tr>
<th>Location chosen</th>
<th>Number of responses</th>
<th>%</th>
<th>Typical codes from children’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location A</td>
<td>N = 57</td>
<td>96.6%</td>
<td>Location A is cheaper and more close to his job</td>
</tr>
<tr>
<td>Location B</td>
<td>N = 2</td>
<td>3.4%</td>
<td>Location B is more expensive and therefore should be better</td>
</tr>
</tbody>
</table>

### Concepts

P.T.1. Without conflicting factors, children could make optimum choices

Note: P.T. means Pre-tests

Table 4. 29 – Children’s responses in task 1

Task 2 required children to decide the best place to build a new desalination station, in order to satisfy the demands of drinkable water. Table 4.30 shows the information given to children for the task.

<table>
<thead>
<tr>
<th></th>
<th>Mari</th>
<th>Zygi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people that will benefit</td>
<td>110 000 people</td>
<td>105 000 people</td>
</tr>
<tr>
<td>Cost of the station</td>
<td>£90 000</td>
<td>£65 000</td>
</tr>
</tbody>
</table>

Table 4.30 - Task 2: information given to children

Children’s responses given for task 2 were grouped according to the decisions that the children reached, and the frequencies of their responses are presented in Table 4.31

<table>
<thead>
<tr>
<th>Location chosen</th>
<th>Number of responses</th>
<th>%</th>
<th>Typical codes from children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mari</td>
<td>N = 40</td>
<td>67.8%</td>
<td>If the station is built in Mari, more people will benefit and although it is more expensive than Zygi it is a better option. (1)</td>
</tr>
<tr>
<td>Zygi</td>
<td>N = 19</td>
<td>32.2%</td>
<td>To build the station in Zygi will be cheaper therefore it is the best choice (2)</td>
</tr>
</tbody>
</table>

### Concepts

P.T.2. Most (67.8%) children decide mainly with the criterion that more people will benefit despite the greater cost

P.T.3. Some (32.2%) children consider that the extra number of people who will benefit is so small that it is not worth the extra cost

P.T.4. With no clear answer, children used their values to take a decision

Table 4.31 – Children’s responses in task 2

Task 3 required from children to decide the best place to buy land in order to build a house in it. Children were given the characteristics for each location as shown in Table 4.32.
Table 4. 32 - Task 3: information given to children

<table>
<thead>
<tr>
<th>Location chosen</th>
<th>Number of responses</th>
<th>%</th>
<th>Typical codes from children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location A</td>
<td>N = 57</td>
<td>96.6</td>
<td>Location A is better than location B in 2 out of 3 criteria and therefore I think it is a better choice (1)</td>
</tr>
<tr>
<td>Location B</td>
<td>N = 2</td>
<td>3.4</td>
<td>Despite the fact that location B will be more expensive than location A, the closer distance to the job makes it a better choice.</td>
</tr>
</tbody>
</table>

**Concepts**

P.T.5. Most (96.6%) children consider all criteria equally important and choose the location (i.e. the answer) that satisfies more than 2 out of 3 criteria

P.T.6. Very few (3.4%) children decide upon the criterion that they consider to be most important

Table 4. 33 – Children’s responses in task 3

Task 4 required children to decide the best place to build a new power station, in order to satisfy the demands of electric power. Table 4.34 shows the information given to children for the task.

Table 4. 34 - Task 4 - information given to children

<table>
<thead>
<tr>
<th></th>
<th>Hirokitia</th>
<th>Zygi</th>
<th>Sotira</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from built-up areas</td>
<td>4 Km</td>
<td>2 Km</td>
<td>5 Km</td>
</tr>
<tr>
<td>Cost of the construction</td>
<td>£200 000</td>
<td>£210 000</td>
<td>£180 000</td>
</tr>
<tr>
<td>Distance from the sea</td>
<td>3Km</td>
<td>1Km</td>
<td>4 Km</td>
</tr>
</tbody>
</table>

Children’s responses given for task 4 were grouped according to the decisions that the children reached, and the frequencies of their responses are presented in Table 4.35
### Chapter 4: Pilot Study Results

<table>
<thead>
<tr>
<th>Location chosen</th>
<th>Number of responses</th>
<th>%</th>
<th>Typical codes from children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirokitia</td>
<td>N = 19</td>
<td>32.2</td>
<td>Hirokitia seems to be the best out of the three places because no one of its characteristics are the worst compared to the other two locations (1)</td>
</tr>
<tr>
<td>Zygi</td>
<td>N = 24</td>
<td>40.7</td>
<td>In my point of view Zygi is the best possible option because it is closer to the sea compared to the other two locations (2)</td>
</tr>
<tr>
<td>Sotira</td>
<td>N = 16</td>
<td>27.1</td>
<td>Sotira is the best place because the station will be placed further away from built-up areas compared to the other two locations (3)</td>
</tr>
</tbody>
</table>

#### Concepts

P.T.7. Children choose the solution that does not have the lower value for any of the criteria set – somewhere in between

P.T.8. Children choose based on the criterion that they consider as most important

P.T.9. Children consider greater distance from built-up areas because it will not create any health problems to the local citizens

<table>
<thead>
<tr>
<th>Emerged Concepts from Pilot study</th>
<th>Emerged Categories from Pilot study</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.I.2. Children as they grow up are given more complex decision making tasks from teachers</td>
<td>1. Age seems to affect children’s decision-making</td>
</tr>
<tr>
<td>T.I.10. The ability to set criteria improves with age</td>
<td>2. Children’s difficulty to search for relevant information to support their decisions</td>
</tr>
<tr>
<td>L.B.6. More children in Year 7 do not believe that one decision would affect other decisions compared to Year 8 children.</td>
<td>3. Curriculum materials require children to search</td>
</tr>
<tr>
<td>T.I.4. Children don’t look for sources of information to support their design decisions</td>
<td></td>
</tr>
<tr>
<td>C.O.2. Children don’t search for relevant information outside class</td>
<td></td>
</tr>
<tr>
<td>C.I.1. Children use their prior experience to select possible materials</td>
<td></td>
</tr>
<tr>
<td>C.C.4 Children search for information relevant to the decision they have to take</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.35 - Children’s responses in task 4

### 4.4 The Development of Categories from Research Concepts

For each group of data that were collected in the pilot studies, a number of concepts have emerged. Groups of similar concepts are grouped together in order to formulate the emerged categories from the pilot study that are presented in Table 4.36. The emerged categories are not listed in any particular order.
<table>
<thead>
<tr>
<th>E.C.4.</th>
<th>Children search for information relevant to the decision they have to take</th>
<th>for relevant information to support their design decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.C.1.</td>
<td>Children shares their decisions with the teacher</td>
<td>4. Types of sources of information include: teacher, internet, books, peers, existing projects, trials</td>
</tr>
<tr>
<td>T.I.5.1 – 5.3</td>
<td>Teachers’ views about sources of information for children in Cyprus, England and Iceland</td>
<td></td>
</tr>
<tr>
<td>T.I.10.</td>
<td>Sources of information –internet</td>
<td></td>
</tr>
<tr>
<td>C.I.3.1</td>
<td>Sources of information: teacher, internet, books, peers, existing projects</td>
<td></td>
</tr>
<tr>
<td>C.I.3.2</td>
<td>Sources of information: teachers, books, existing projects, trial and error, internet</td>
<td></td>
</tr>
<tr>
<td>L.B.1.</td>
<td>Children select ideas from their everyday activities and their interests</td>
<td></td>
</tr>
<tr>
<td>L.B.2.</td>
<td>Sources of information: existing projects, teachers, peers, materials properties</td>
<td></td>
</tr>
<tr>
<td>L.B.3.</td>
<td>Children’s sources of information: teacher, peers, existing projects, internet, books, trials</td>
<td></td>
</tr>
<tr>
<td>C.O.3.</td>
<td>Children use their teacher as a source of information</td>
<td></td>
</tr>
<tr>
<td>C.O.4.</td>
<td>Children use their peers as a source of information</td>
<td></td>
</tr>
<tr>
<td>C.O.5.</td>
<td>Children use previous years’ projects as a source of information</td>
<td></td>
</tr>
<tr>
<td>C.O.7.</td>
<td>Children’s sources of information include teachers, peers, existing projects, internet, books, trials</td>
<td></td>
</tr>
<tr>
<td>T.I.7.</td>
<td>Difficulty to collect information from the book</td>
<td></td>
</tr>
<tr>
<td>T.I.8.</td>
<td>Difficulty to set criteria</td>
<td>8. Children face difficulty in setting evaluation criteria for their decisions.</td>
</tr>
<tr>
<td>T.I.9.</td>
<td>Set criteria such as aesthetics and style</td>
<td></td>
</tr>
<tr>
<td>C.I.4.</td>
<td>Children don’t use evaluation criteria for their design projects</td>
<td></td>
</tr>
<tr>
<td>C.O.6.</td>
<td>Difficulty to set evaluation criteria</td>
<td></td>
</tr>
<tr>
<td>P.T.8.</td>
<td>Children choose based on the criterion that they considers as most important</td>
<td></td>
</tr>
<tr>
<td>P.T.5.</td>
<td>Most (96.6%) children consider all criteria equally important and choose the location (i.e. the answer) which satisfies more 2 out of 3 criteria</td>
<td></td>
</tr>
<tr>
<td>P.T.3.</td>
<td>Some (32.2%) children consider that the extra number of people will benefit is so small that it is not worth the extra cost</td>
<td></td>
</tr>
<tr>
<td>C.C.5</td>
<td>Children take decisions upon the appropriate, appearance, materials, mechanisms, decoration, electrical components etc.</td>
<td></td>
</tr>
<tr>
<td>E.C.3.</td>
<td>Children take decisions upon materials, time and production</td>
<td></td>
</tr>
<tr>
<td>T.I.13.</td>
<td>Don’t want to spent time designing</td>
<td>9. Many times children do not have the motivation to think about a design</td>
</tr>
<tr>
<td>T.I.14.</td>
<td>No motivation to think for decisions</td>
<td></td>
</tr>
<tr>
<td>C.I.4.</td>
<td>Children don’t use evaluation criteria for their design projects</td>
<td></td>
</tr>
<tr>
<td>L.B.1.</td>
<td>Children select ideas from their everyday activities and their interests</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>C.O.1.</td>
<td>Lack of motivation for the designing part of the project</td>
<td></td>
</tr>
<tr>
<td>C.O.2.</td>
<td>Children don’t search for relevant information outside class</td>
<td></td>
</tr>
<tr>
<td>T.I.4.</td>
<td>Children don’t look for sources of information to support their design decisions</td>
<td></td>
</tr>
<tr>
<td>C.I.5.</td>
<td>Children refer to specific criteria in their personal decisions (e.g. mobile phones)</td>
<td></td>
</tr>
<tr>
<td>T.I.12.</td>
<td>No formal instruction on how to make decisions</td>
<td></td>
</tr>
<tr>
<td>T.I.1.</td>
<td>Teachers’ expectations affect the nature of decision-making task that is given to children</td>
<td></td>
</tr>
<tr>
<td>T.I.15.</td>
<td>Teachers don’t know if children can transfer skills</td>
<td></td>
</tr>
<tr>
<td>C.I.6.</td>
<td>Some children in year 8 refer to some transfer of skills</td>
<td></td>
</tr>
<tr>
<td>L.B.4.</td>
<td>Most children believe decisions already taken will not affect next decisions</td>
<td></td>
</tr>
<tr>
<td>L.B.5.</td>
<td>Some children believe decisions already taken will affect next decisions</td>
<td></td>
</tr>
<tr>
<td>C.I.1.</td>
<td>Children use their prior experience to select possible materials</td>
<td></td>
</tr>
<tr>
<td>C.I.2.</td>
<td>Peers influence children’s own decisions</td>
<td></td>
</tr>
<tr>
<td>C.O.4.</td>
<td>Children use their peers as a source of information</td>
<td></td>
</tr>
<tr>
<td>E.C.4.</td>
<td>Children search for information relevant to the decision they have to take</td>
<td></td>
</tr>
<tr>
<td>T.I.3.</td>
<td>NC in all countries includes decision-making opportunities, but in practice it is difficult to apply those decision-making opportunities.</td>
<td></td>
</tr>
<tr>
<td>C.C.1</td>
<td>Children identify design decisions taken by manufacturers for existing products</td>
<td></td>
</tr>
<tr>
<td>C.C.2</td>
<td>Children decide the reason for making a certain design.</td>
<td></td>
</tr>
<tr>
<td>C.C.3</td>
<td>Children choose their own project within a special topic (eg. mechanisms or electronics)</td>
<td></td>
</tr>
<tr>
<td>C.C.5</td>
<td>Children take decisions upon the appropriate appearance, materials, mechanisms, decoration, electrical components etc.</td>
<td></td>
</tr>
<tr>
<td>E.C.2</td>
<td>Children explains design decisions taken by manufacturers for existing products</td>
<td></td>
</tr>
<tr>
<td>E.C.3</td>
<td>Children take decisions on materials, time and production</td>
<td></td>
</tr>
<tr>
<td>E.C.5</td>
<td>Children justify decisions regarding the choice of materials</td>
<td></td>
</tr>
<tr>
<td>I.C.1.</td>
<td>Children consider factors such as appearance, ergonomics and sustainability in their design decisions</td>
<td></td>
</tr>
<tr>
<td>I.C.2.</td>
<td>Children discuss their decisions with peers</td>
<td></td>
</tr>
<tr>
<td>I.C.3.</td>
<td>Children design alternative solutions</td>
<td></td>
</tr>
</tbody>
</table>

10. Children define more evaluation criteria for their personal decisions

11. Teachers’ own ideas affect their teaching in the area of decision-making

12. The transfer of decision-making skills to other areas is not evident

13. Children are expected to transfer decision-making skills within the same domain

14. Peers affect children’s design decisions

15. Curriculum materials in all three countries include decision-making opportunities for children
### Table 4.36 - Emerged categories from the pilot study

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.C.4.</td>
<td>Children based their choices on technical solutions</td>
</tr>
<tr>
<td>L.B.4.</td>
<td>Children believe decisions already taken will <em>not</em> affect next decisions</td>
</tr>
<tr>
<td>P.T.7.</td>
<td>Children choose the solution that does not have the lower value for any of the criteria set – somewhere in between</td>
</tr>
<tr>
<td>P.T.8.</td>
<td>Children choose based on the criterion that they consider as most important</td>
</tr>
<tr>
<td>P.T.1.</td>
<td>Without conflicting factors, children could make optimum choices</td>
</tr>
<tr>
<td>P.T.2.</td>
<td>Most (67.8%) children decide mainly with the criterion that more people will benefit despite the greater cost</td>
</tr>
<tr>
<td>P.T.9.</td>
<td>Children consider greater distance from built-up areas important because it will not create any health problems to the local citizens</td>
</tr>
<tr>
<td>P.T.3.</td>
<td>Some (32.2%) children consider that the extra number of people will benefit is so small that it is not worth the extra cost</td>
</tr>
<tr>
<td>P.T.4.</td>
<td>With no clear answer, children used their values</td>
</tr>
<tr>
<td>L.B.3.</td>
<td>Children’s sources of information: Teacher, Peers, Existing projects, Internet, Books, Trials</td>
</tr>
<tr>
<td>C.O.2.</td>
<td>Children don’t search for relevant information outside class</td>
</tr>
<tr>
<td>C.O.7.</td>
<td>Children’s sources of information include teachers, peers, existing projects, internet, books, trials</td>
</tr>
<tr>
<td>C.I.4.</td>
<td>Children don’t use evaluation criteria for their design projects</td>
</tr>
<tr>
<td>C.I.5.</td>
<td>Children refer to specific criteria in their personal decisions (e.g. mobile phones)</td>
</tr>
<tr>
<td>C.O.6.</td>
<td>Difficulty to set evaluation criteria</td>
</tr>
<tr>
<td>L.B.4.</td>
<td>Children believe decisions already taken will <em>not</em> affect next decisions</td>
</tr>
<tr>
<td>P.T.7.</td>
<td>Children choose the solution that does not have the lower value for any of the criteria set – in between</td>
</tr>
<tr>
<td>P.T.8.</td>
<td>Children choose based on the criterion that they consider as most important</td>
</tr>
<tr>
<td>P.T.1.</td>
<td>Without conflicting factors, children could make optimum choices</td>
</tr>
<tr>
<td>C.I.1.</td>
<td>Children use their prior experience to select possible materials</td>
</tr>
</tbody>
</table>

### 4.5 Changes to the Main Study as a Result of the Pilot Studies

Pilot studies were conducted in order to pre-test the data collection instruments to be used in the research study. Through that process the researcher also gained experience in the use of...
the research instruments. Some issues that were pre-tested during the pilot study included possible problems with the wording or with the nature of the research instruments. Another factor was the estimation of the time needed to complete the tasks and whether the tools were capturing the necessary data successfully (Robson, 2002).

The children’s interviews from the pilot study were considered to be successful in terms of the time needed and their content. The only change to the interviews for the main study was asking the children to add some more practical examples, such as specific topics for their design tasks and descriptions of some of their personal decisions.

During the pilot study some observations were performed in order to examine children’s decision-making behaviour in practice while designing. Those observations were not structured since at that stage their intention was to obtain any possible information relevant to the research questions. Based on the outcomes of the pilot study, a new semi-structured observation protocol was designed for the main study (Appendix 3.3). The observations were intended to collect information on the activities that were taking place in the class during the teacher-children interactions whilst children were working on a given design task.

The pre-test undertaken by the children during the pilot study was considered to be time consuming (as it needed more than an hour for completion) and in some cases it was difficult for the children to understand its requirements. A new test was designed that included only 2 tasks (Appendix 4.1). The first task required children to select the best place to build an electric power station based on information given to them and the second task requested children to take a personal decision. More specifically, the children were asked to choose a mobile phone that suited them based on information given to them. The new test was delivered to children twice, before and after their design task.

Children’s log-books were also modified from the ones used in the pilot study. The new log-books were shorter and required children to consider any possible choices. They were asked to think of the consequences of those possible options and to take a design decision based on them. A special log-book form was designed and administrated to children during their design task (Appendix 4.2).
Summary

The purpose of the pilot study was to examine the effectiveness of the data collection methods and to examine the effectiveness of the pilot research design (first action cycle). The data collection tools and research procedures were tested through the pilot study. For the analysis of the pilot study outcomes, grounded theory analysis was employed in where teachers’ codes were grouped into concepts and afterwards concepts were grouped into emerged categories.
Chapter 5: Main Study Results

Overview: This chapter presents the data analysis methods used and the outcomes of the main study. The analysis was conducted based on the research questions and to some pre-set categories that emerged from the pilot studies. Some new categories that emerged from the main study are also presented. The chapter will present the data analysis of interviews, pre-tests, post-tests, observations and log-books undertaken in the main study.

5.1 The Main Study

The purpose of the main study was to investigate children’s decision-making strategies while designing in design and technology education. After the implementation and the analysis of the pilot studies the initial design of the main study was finalised taking the pilot study results into account. More specifically in the main study the first step was to collect information from children’s interviews before any design activities. After the interview pre-tests were completed by the children, and then a design task was given to them. The children were asked to keep log-books recording their design decisions during their designing and they were also observed in the classroom/workshop by two separate researchers. After the completion of children’s design projects, a further interview and post-test were administrated to them (for more information see Section 3.6.3).

5.2 Data Analysis Methods

There is no singularly appropriate way to conduct qualitative data analysis, although there is general agreement that analysis is an on-going, iterative process that begins in the early stages of data collection and continues throughout the study (Campbell and Gregor 2004).

Miles and Huberman (1994) define data analysis as consisting of three concurrent flows of activity: (1) Data reduction; reduction of the data helps to sharpen, sort, focus, discard, and organize the data, (2) Data display; present the data in an organized, compressed way so that conclusions can be more easily drawn, and (3) Conclusion drawing/verification; the researcher begins to find and make meaning.

For the purpose of the current research, the data collection protocols (interviews, observation, log-books and tests) were segmented and each segment was coded. These codes were related
to the research questions and the categories that emerged from the literature reviewed and the pilot studies (Miles and Huberman, 1994). Although the areas of interest had been predefined, the analysis was responsive to additional relevant factors that could emerge in the data (Cohen et al., 2007; Creswell, 2007). More specifically the following steps followed for the data analysis (Miles and Huberman, 1994).

1. Affixing codes to a set of field notes drawn from data collection
2. Noting reflections or other remarks in the margin
3. Sorting or shifting through the materials to identify similar phrases, relationships between themes, distinct differences between subgroups and common sequences
4. Identifying themes or patterns — ideas, concepts, behaviours, interactions, incidents, terminology or phrases used.
5. Isolating patterns and processes, commonalties and differences, and taking them out to the filed in the next wave of data collection
6. Gradually elaborating a small set of generalisations that cover the consistencies discerned in the database
7. Organizing them into coherent categories - that summarize and bring meaning to the text.

5.2.1 Data Analysis Pre-set Categories

The research questions (Chapter 1, Section 1.2) of the study and the findings of the pilot study (Chapter 4) identified a number of issues relevant to children’s decision making strategies. Those issues will formulate some initial pre-set categories that the analysis of the data collected will be based on. At the same time some new issues with ideas or concepts that the research did not consider in advance will also be identified if they were to emerge from the data analysis. This approach allows for new categories to emerge from the main study data and for these to be presented as the emergent categories of the study.

5.3 The Results of the Main Study

The main study collected data from various sources, pre-tests, post-tests and interviews with children before and after the design task set to the children, and log-books completed and observations made during the children’s design task (more details can be found in section 3.6.3). The results from each of the data collection tools will beanalysed and presented independently and possible interrelations, similarities or differences between them will be discussed in the Chapter 7 (Discussion).
An identification (ID) number was added to each data protocol collected. The code “child” was given to each individual case from which data was collected. The children who participated in the study were from different age groups, and Table 5.1 presents how children were coded within a different year group. For example, when reference is made to child 3 interview, this child belongs to the Year 7 age group (age 12-13), and when reference is made to child 96 in pre-test, post-test and logbooks, then this child belongs to the Year 9 age group (age 14-15).

<table>
<thead>
<tr>
<th>Year Group</th>
<th>Interviews</th>
<th>Pre-test - Post-test - Logbooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 7 (age 12-13)</td>
<td>Child 1-5</td>
<td>Child 1 – 37</td>
</tr>
<tr>
<td>Year 8 (age 13-14)</td>
<td>Child 6-10</td>
<td>Child 38-73</td>
</tr>
<tr>
<td>Year 9 (age 14-15)</td>
<td>Child 11-15</td>
<td>Child 74-110</td>
</tr>
</tbody>
</table>

Table 5.1 - Categorization of children within different age groups

5.3.1 Children’s Interviews

Children’s interviews were recorded and transcribed verbatim, making the transcripts the centre of the analysis. Children’s decision-making strategies were analysed and categorised in relation to research questions and the pre-set categories that had emerged from the pilot study (Chapter 4). Some representative codes related to the research were selected and presented in this section. The following is a small example (Table 5.2) of the analysis of the interviews from the main study. More the detailed coding of children’s interviews can be found in Annex.

- Example of Analysis

The relevant codes from children’s interviews were selected and copied into a table. The codes that were relevant to a specific research category were highlighted and in the left column of the Table a representative code was reported.
5.3.1.1 Results from Pre-observational Interviews

The intention of pre-observational interviews, as explained in Chapter 3 was to identify some initial general factors that are affecting children’s decision making strategies. The interview included questions concerning their decision-making outside and inside school. The results will be based on the pre-set categories developed from the pilot study and on some new emerging categories.

- Sources of Information

One of the outcomes of the pre-observational interview was the sources of information that children used in order to improve their theoretical background before taking a certain decision. During the interviews children were asked to explain if they used any kind of sources of information before taking a design decision. For this project children reported sources of information that they had used both for some personal decisions and for decisions taken in the subject of design and technology. Table 5.3 shows some typical codes from children’s interviews and the frequencies that a certain source of information was mentioned in children’s interviews.

<table>
<thead>
<tr>
<th>Code</th>
<th>Source of information</th>
<th>Child number</th>
<th>Codes from interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.I.1</td>
<td>Teacher</td>
<td>Child 1</td>
<td>Teacher: Where can you get information to help you take your decision? Child 1: First I shall ask my <strong>teacher</strong> to give me some information on the area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child 6</td>
<td>Child 6: The safest way is to <strong>discuss that with my teacher</strong>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child 9</td>
<td>Child 9: I possibly will ask the <strong>teacher</strong></td>
</tr>
<tr>
<td>S.I.2</td>
<td>Subject Book</td>
<td>Child 2</td>
<td>Child 2: I look in our <strong>design and technology book</strong> in order to see information on the mechanisms mainly and less frequently to find ideas about the shape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child 10</td>
<td>Child 10: The book usually includes many examples of the mechanism or equipment to use and some drawings for the initial ideas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child 15</td>
<td>Child 15: The subject book had some examples relevant to my project, so I use it to get some information.</td>
</tr>
</tbody>
</table>

Table 5.2 – Example of interview analysis
### Table 5.3 – Sources of information from the pre-observational interviews

<table>
<thead>
<tr>
<th>Source of Information (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher (N=13)</td>
<td>12-13</td>
<td>5</td>
<td>Child 2: I think that the best option is to ask your teacher about relevant information</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>4</td>
<td>Child 6: I shall ask my teacher’s opinion so that I shall get the information that I need for my design project</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 15: Maybe I shall ask my teacher since he knows more about those issues</td>
</tr>
<tr>
<td>Subject Book (N=5)</td>
<td>12-13</td>
<td>2</td>
<td>Child 1: First I shall have a look in my book and if I don’t find the information that I need, then I shall search for them though the internet</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 7: The book includes some information</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>1</td>
<td>Child 12: I usually use the design and technology book to find relevant information</td>
</tr>
<tr>
<td>Internet (N=10)</td>
<td>12-13</td>
<td>3</td>
<td>Child 4: Because I don’t know much stuff about those issues I shall try to find them through the internet</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 6: I shall have a look at the internet to find relevant information</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 10: I usually do research through the internet and I collect information for what I want</td>
</tr>
<tr>
<td>Peers (N=12)</td>
<td>12-13</td>
<td>2</td>
<td>Child 1: I get some ideas from my friends when I see them do something that I like</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>5</td>
<td>Child 6: Of course I shall get some ideas from my friends</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>5</td>
<td>Child 11: For example when I wanted a mobile phone, I asked some of my friends about their mobile phones, and I got some ideas about which one to buy for myself</td>
</tr>
<tr>
<td>Additional Books (N=5)</td>
<td>12-13</td>
<td>2</td>
<td>Child 1: I shall search for information in the subject book and in some additional books in my home if I have some</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 8: I shall try to find some information on the internet and in other books</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 13: I shall do a little market research and maybe I shall find information in some books or magazines</td>
</tr>
<tr>
<td>Content Experts (N=2)</td>
<td>12-13</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 7: I asked for information about the phone from the people in the shop since they are experts on that area</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>1</td>
<td>Child 14: I shall ask someone expert on that area to give me information that I want to know</td>
</tr>
<tr>
<td>Market Research for Personal Purchasing (N=6)</td>
<td>12-13</td>
<td>1</td>
<td>Child 3: I shall search some shops and I shall find the best available deal</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 10: After a search on the the internet I decided to go to a shop to see personally some mobile phones before I decided which phone to buy</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 14: I had three mobile phones in mind and then I went to some shops to see if they have any offers on and decided on the one I found more attractive</td>
</tr>
</tbody>
</table>
**Evaluation Criteria**

During the pre-observational interview children were asked to explain if they used any criteria to base their decisions on and if yes what those criteria were. A number of criteria were mentioned by children both for personal decisions and for decisions taken in design and technology classes. Table 5.4 presents some representative codes from children’s interviews and the frequencies of the criteria mentioned.

<table>
<thead>
<tr>
<th>Evaluation Criteria (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>12-13</td>
<td>3</td>
<td>Child 1: I used to buy things that I consider to be attractive</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 10: I took my decision mainly based on the product attractiveness. It is important for something to be attractive</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 15: The appearance of the product is important to me, I like something when I found it attractive</td>
</tr>
<tr>
<td>Cost - for personal purchasing (N=9)</td>
<td>12-13</td>
<td>4</td>
<td>Child 3: I compare the prices and then take a decision, I don’t usually go for something expensive</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 7: A very important criterion for me was the price of the mobile phone. I didn’t wanted something very expensive</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 13: I shall check if the prices are within my budget and then take a decision with this constraint</td>
</tr>
<tr>
<td>Cost for design projects (N=1)</td>
<td>12-13</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>1</td>
<td>Child 15: I considered the cost of the materials that I was going to use for our design</td>
</tr>
<tr>
<td>Brand Name (N=6)</td>
<td>12-13</td>
<td>2</td>
<td>Child 4: The first think I shall consider when buying the mobile phone is the brand name</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 6: I only search for a specific mobile phone brand name, which I consider to be reliable</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 14: An important factor in my decision will be played by the brand name of the phone that I shall buy</td>
</tr>
<tr>
<td>Ability to set criteria for personal decisions (N=10)</td>
<td>12-13</td>
<td>3</td>
<td>Child 3: I shall look at the shape, colours, the price and the memory of the phone and then I shall take my decision</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 7: I would like to buy a mobile phone that has good camera, good memory and that has nice appearance. All those issues are important to me</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 11: I wanted some specific technical features like good memory, Bluetooth, wifi and to be a good price, so I found a model that fulfils those criteria</td>
</tr>
</tbody>
</table>

Table 5.4– Children’s evaluation criteria from pre-observational interviews
• **Relative Importance of the Criterion**

During the pre-observational interviews children were able to identify the most important criterion for their personal purchasing decisions. The results are presented in Table 5.5.

<table>
<thead>
<tr>
<th>Importance of Criterion (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to specify the most important criterion for their personal decisions (N=13)</td>
<td>12-13</td>
<td>5</td>
<td>Child 4: For me the most important criterion is the memory of the phone, so I will base my decision on that and then I shall consider the cost</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>4</td>
<td>Child 8: Well, I shall first consider the cost of the phone and then look to other features</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 15: I shall try to find something that is a good for the technical features that I want, but the most important is how it looks like</td>
</tr>
<tr>
<td>Cost (N=7)</td>
<td>12-13</td>
<td>2</td>
<td>Child 3: The most important factor is the price, if the product is within my budget then I look to other issues</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 7: Important role in my choice is the price of the product and then the others</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 12: The first thing that I shall consider is the cost of the phone</td>
</tr>
<tr>
<td>Attractiveness (N=6)</td>
<td>12-13</td>
<td>3</td>
<td>Child 4: The appearance of the product is the most important criterion for my decision</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 6: When I am in between two choices, I always go for the one that I found more attractive</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>1</td>
<td>Child 12: First I will look for the appearance, and then I will look for the technical characteristics</td>
</tr>
</tbody>
</table>

Table 5.5 - Relative Importance of the Criterion from Pre-observational Interview

• **Decision-Making Opportunities**

During the pre-observational interviews children were asked to talk about the decision-making opportunities they had during their involvement with design and technology activities in school environment. Based on the interviews, a number of decision-making opportunities were identified. The results from the responses and the frequencies of each decision-making opportunity are summarised in Table 5.6.
Table 5.6 - Children’s decision-making opportunities from pre-observational interview

- **Transfer of Skills**

The pre-observational interviews aimed to explore if children believe that school subjects in general and design and technology in particular offers to them skills that they use in other areas of life outside school. Children were asked to explain their thoughts on how they use the knowledge and skills they learn in school in their life outside school activities. Children’s responses and the frequencies of each response are shown in Table 5.7.
Chapter 5: Main Study Results

Transfer of Skills (N=15)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-13</td>
<td>5</td>
<td>Child 1: I don’t believe that what we are learning in schools can be used in other areas of life</td>
</tr>
<tr>
<td>13-14</td>
<td>4</td>
<td>Child 6: I don’t remember using some skills I’ve learned in class in any other areas of life</td>
</tr>
<tr>
<td>14-15</td>
<td>3</td>
<td>Child 14: I think I don’t transfer any skills from school to what I am doing outside school</td>
</tr>
</tbody>
</table>

Children believe that they transfer some skills from the subject to other areas of life (N=3)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Frequency Used (N=3)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-13</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>13-14</td>
<td>1</td>
<td>Child 10: Maybe we use skills that we learned in design and technology in other issues outside school without realising that</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td>Child 15: When you go to buy a pair of shoes, most of the times you’re choosing among two or three pairs and you have to take a decision. It is similar to what we are doing in design and technology when we have to choose among alternative ideas</td>
</tr>
</tbody>
</table>

Table 5.7 - Transfer of skills from pre-observational interview

- **Pre-observational Interviews Main Findings**

  From the results of the pre-observational interviews with children it can be seen that children used various sources of information in order to shape their knowledge before taking a design decision for their design and technology projects. Teachers, the internet and peers were the most frequent sources of information reported on children’s interviews. Other sources mentioned by children, includes books, content experts and market research. Children also identified various evaluation criteria for their decisions. At that stage children were referring both to their design decisions in school and to their personal decisions outside school. From the results it can be seen that the attractiveness was the most frequent criterion used. The cost turned out to be an important criterion for their personal purchasing decisions, but at the same time was less important for their design decisions in design and technology projects.

  Children identified some decisions that are frequently required from their teachers to be taken during design and technology projects and they reported the appropriate materials and the shape of their design as the most common decisions. They also complained that school in general did not give them adequate decision-making opportunities in order to improve this skill and that they had not observed transferring any decision-making skills from school environment to other activities of their life.
5.3.1.2 Post-observational Interviews

Post-observational interviews were conducted in order to investigate how children took their design decisions on a certain project that was given to them (more detailed description about the methodology can be found in Chapter 3). The interview protocol was very similar to the pre-observational interview but this time the emphasis was in the activities they performed in design and technology classes and to the design task they completed before the post-observational interview. The results of the analysis is presented in the following tables, based on the pre-set categories developed from the pilot study and the literature review, and on some new categories that emerged from the data. The analysis followed the same principles as the analysis of the pre-observational interviews and an example can be found in Table 5.2.

- **Sources of Information**

After children completed their design project, during the interview they identified the sources of information they had used for their design decisions. Children explained how often they used sources of information and they named the sources of information they used for this particular project and generally in design and technology classes. Their responses were grouped based on the pre-set categories and are presented in Table 5.8.

<table>
<thead>
<tr>
<th>Source of Information (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher (N=11)</td>
<td>12-13</td>
<td>5</td>
<td>Child 1: I asked my teacher to guide me about the different properties of materials</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>4</td>
<td>Child 8: the easiest way to find information is to ask your teacher</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 12: I shall search for information first and then I will discuss them with teacher to tell me his opinion</td>
</tr>
<tr>
<td>Subject Book (N=9)</td>
<td>12-13</td>
<td>1</td>
<td>Child 1: The book has examples that help me decide on some possible materials to use</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>4</td>
<td>Child 7: I used the subject book to get ideas about the mechanism that I used</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 13: from the subject book I found information about the electrical components that were available to use and help me select the appropriate components for my project</td>
</tr>
<tr>
<td>Internet (N=7)</td>
<td>12-13</td>
<td>2</td>
<td>Child 1: I first look in my book and then at the internet to find the information I need</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 6: I looked at the internet because I know where to find the information that I want</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 15: I use the internet to find out the information that I don’t know.</td>
</tr>
<tr>
<td>Peers (N=8)</td>
<td>12-13</td>
<td>2</td>
<td>Child 5: Because some of my friends decided to make the logo of their team I thought that is good idea to do it as well</td>
</tr>
<tr>
<td>Source</td>
<td>Age</td>
<td>N</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------</td>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Additional Books</strong> (N=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>3</td>
<td></td>
<td>Child 7: I discussed my ideas with my friends and I found similarities in our designs, like the decoration for example</td>
</tr>
<tr>
<td>14-15</td>
<td>3</td>
<td></td>
<td>Child 14: In the class you are always observing what other people are doing and if there is something that you like then you will be influenced by that</td>
</tr>
<tr>
<td><strong>Trial and Error – Modelling</strong> (N=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>1</td>
<td></td>
<td>Child 9: I try to used cardboard first to check the movement of the mechanism and then I used plastic to make my real design project</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td></td>
<td>Child 15: I worked first with some of the materials in order to gain an understanding of their properties and then took the decision of which materials to use</td>
</tr>
<tr>
<td><strong>Existing Projects</strong> (N=6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>1</td>
<td></td>
<td>Child 1: from other projects that were available in the workshop I found information about possible materials or shapes</td>
</tr>
<tr>
<td>13-14</td>
<td>2</td>
<td></td>
<td>Child 8: I investigated some projects from previous years in the workshop and I found an interesting mechanism which I used for my own design as well</td>
</tr>
<tr>
<td>14-15</td>
<td>3</td>
<td></td>
<td>Child 14: from some existing projects that I explored in the workshop, I took some ideas about the possible materials that I can use and some ideas about the electrical circuits</td>
</tr>
<tr>
<td><strong>Content Experts</strong> (N=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>1</td>
<td></td>
<td>Child 6: I asked people that had made similar designs and they are experts on that area</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td></td>
<td>Child 15: I shall talk with people that have experience on the design of electronic systems to guide me</td>
</tr>
<tr>
<td><strong>Personal Interests</strong> (N=5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>2</td>
<td></td>
<td>Child 6: because I love volleyball and I play very often I decided to make my idea based on that</td>
</tr>
<tr>
<td>14-15</td>
<td>3</td>
<td></td>
<td>Child 12: always my personal hobbies or my favourite singers have an effect on the decoration of my designs</td>
</tr>
<tr>
<td><strong>Existing Knowledge</strong> (N=7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>2</td>
<td></td>
<td>Child 3: I just did it myself without looking for anything</td>
</tr>
<tr>
<td>13-14</td>
<td>3</td>
<td></td>
<td>Child 6: I didn’t see it anywhere it just came to my mind this idea and I made it</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td></td>
<td>Child 11: well I didn’t use any source of information since I knew how to do it from my previous work</td>
</tr>
<tr>
<td><strong>Television</strong> (N=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>2</td>
<td></td>
<td>Child 4: I was inspired by a documentary that I watched on the television and I decided to do something like that</td>
</tr>
<tr>
<td>13-14</td>
<td>1</td>
<td></td>
<td>Child 8: I got some ideas on the appearance of my design from a TV show</td>
</tr>
<tr>
<td>14-15</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.8 – Sources of information from post-observational interview
• **Evaluation Criteria**

During the post-observational interviews children identified the evaluation criteria that they based their choices on for their design projects. The criteria they used in their design projects were grouped and are summarised in Table 5.9.

<table>
<thead>
<tr>
<th>Evaluation Criteria (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness (N=6)</td>
<td>12-13</td>
<td>2</td>
<td>Child 5: I decided to use the acrylic plastic because it is more attractive than PVC</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 10: I decided to choose that idea because it looks more attractive than the others</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 11: I decided to choose the idea that I found more attractive than the others</td>
</tr>
<tr>
<td>Time limitations (N=4)</td>
<td>12-13</td>
<td>1</td>
<td>Child 1: I decided to use the PVC plastic because the Acrylic plastic was very brittle and needs more time to be shaped</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 8: I always have in mind the available time, because sometimes I have not finished my projects because I wanted to do something complicated</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>1</td>
<td>Child 12: Well I didn’t have time to check everything so I just decide based on my previous experience</td>
</tr>
<tr>
<td>Cost for design projects (N=2)</td>
<td>12-13</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 14: We decided to use batteries instead of a photovoltaic cells because of the cost</td>
</tr>
<tr>
<td>Strength (N=8)</td>
<td>12-13</td>
<td>2</td>
<td>Child 1: I shall use the wooden wheels because they are more stable than the cardboard ones. It may run a little slower but at least it will be strong enough</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 7: Because the strength of cardboard is not good enough I will use the wooden wheels</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 11: I prefer to have high strength and for it to be a more reliable design than use soft materials even if with them it will function better</td>
</tr>
<tr>
<td>Functionality (N=4)</td>
<td>12-13</td>
<td>1</td>
<td>Child 2: If we use solar power it will work only when there is sunlight, and I decided to use normal batteries instead</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 9: I think it will work better if I use gears instead of pulleys</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 13: In my electric circuit I used a transistor instead of a thyristor because it suits the purpose of my project better</td>
</tr>
<tr>
<td>Ability to set criteria for design projects (N=5)</td>
<td>12-13</td>
<td>1</td>
<td>Child 3: It is important to have some criteria in mind because it’s easier to take a decision</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 8: The appearance of the design is normally my first criterion and then I take into account other issues like strength, cost etc</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 13: For the purpose of this project my first criterion was to work according to the specification and to design something attractive</td>
</tr>
</tbody>
</table>

Table 5.9 - Children’s evaluation criteria from post-observational interviews
• **Decision-Making Opportunities**

Children need to take decision-making opportunities in their design and technology classes in order to improve their decision-making skills. During the post-observational interview children were asked to say if they normally have decision-making opportunities in their classes and to name some of them. The results of children’s responses and the frequencies of the opportunities named by children are shown in Table 5.10.

<table>
<thead>
<tr>
<th>Decision-making Opportunities (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from Children Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose the appropriate materials (N=10)</td>
<td>12-13</td>
<td>3</td>
<td>Child 2: I had the opportunity to select the appropriate materials for my design project</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 9: I chose to use soft material because I wanted to spend more time for the mechanism instead of shaping the materials</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 14: One of the opportunities was to decide the appropriate materials and electrical components of the design project</td>
</tr>
<tr>
<td>Choose the design shape (N=6)</td>
<td>12-13</td>
<td>2</td>
<td>Child 5: The shape of my design was my own decision</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 7: I decided to make that shape because is one of my personal interests</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 12: The first decision that I took was the shape of my design</td>
</tr>
<tr>
<td>Choose the appropriate mechanisms or electrical components (N=9)</td>
<td>12-13</td>
<td>2</td>
<td>Child 4: The type of energy and the electrical circuit was my own choice</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>3</td>
<td>Child 7: We decided the type of mechanism to use for my car model</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 12: I decided which electrical components was appropriate for my project</td>
</tr>
<tr>
<td>Choose the purpose of their design (N=6)</td>
<td>12-13</td>
<td>1</td>
<td>Child 3: I decided the purpose for which I shall use my design</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 6: We have some opportunities to take decisions, in that case I chose the purpose of designing that</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>3</td>
<td>Child 11: We decided what will be the purpose of the product we made</td>
</tr>
</tbody>
</table>

Table 5.10– Children’s decision-making opportunities from post-observational interviews

• **Other issues that were involved in children’s decision-making from post observational interviews**

During the post-observational interviews, some other issues relevant to children decision-making strategies emerged from the data analysis. Factors include lack of motivation, lack of
confidence, heuristics approaches, children’s alternative ideas and difficulties they faced. The results of the responses and the frequencies of each factor are shown in Table 5.11.

<table>
<thead>
<tr>
<th>Factors affecting children’s decision-making (N=15)</th>
<th>Age Group</th>
<th>Frequency Used (N=5)</th>
<th>Codes from children interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of decision-making (N=6)</td>
<td>12-13</td>
<td>2</td>
<td>Child 5: It is important for us to improve our decision-making skills because are useful in our personal life</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 10: It is very important to learn about decision making, so we can take more logical decisions</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 11: To learn about decision-making will help us in our life’s decisions and therefore is important for me</td>
</tr>
<tr>
<td>Lack Motivation (N=5)</td>
<td>12-13</td>
<td>2</td>
<td>Child 2: Sometimes when I am doing something that is not interesting to me, then I don’t spend much time to design it</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 8: If the design is something that i like and is interesting then i am spending more time on design because i want to do it very good</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 14: Because this project was interesting I had high motivation and more careful decision-making compared to last year’s projects that was not so interesting for me</td>
</tr>
<tr>
<td>Rule of Thumb (N=6)</td>
<td>12-13</td>
<td>2</td>
<td>Child 2: Well i didn’t used any specific technique to take my decision, it just came to my mind</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>2</td>
<td>Child 8: It depends how important is the decision to me, sometimes it’s not worth to search for many alternatives and spend time and you just take a quick decision for your project</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 12: Some decisions need careful consideration and investigation but most of the times I just take an instant decision that suits the requirements</td>
</tr>
<tr>
<td>Children decide on their best idea and then draw some others (N=9)</td>
<td>12-13</td>
<td>3</td>
<td>Child 4: I draw the design idea that i shall make for my project and then I draw some additional to fulfil the marking scheme</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>4</td>
<td>Child 8: Most times, I have in mind what i want to do and then I draw some others because is part of our marking</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>2</td>
<td>Child 13: I know from the beginning of the project the one that i shall make at the end but because teachers ask for alternative ideas that’s why i draw 3-4 additional ideas</td>
</tr>
<tr>
<td>Children draw their ideas and then take a decision (N=4)</td>
<td>12-13</td>
<td>1</td>
<td>Child 1: I normally draw some design ideas that I like and then decide for the best of them</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 7: I draw all my ideas and then I choose the one that I like more</td>
</tr>
</tbody>
</table>
Child 15: First, I drew all my possible ideas and then I am thinking which one to make

Difficulties Identified (N=5)

<table>
<thead>
<tr>
<th>Age</th>
<th>Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-15</td>
<td>2</td>
<td>Child 15: First, I drew all my possible ideas and then I am thinking which one to make</td>
</tr>
<tr>
<td>12-13</td>
<td>1</td>
<td>Teacher: Which source of energy will you use? Child 2: I don’t know which one to choose</td>
</tr>
<tr>
<td>13-14</td>
<td>2</td>
<td>Child 7: Some children are not confident enough to feel sure about their decisions Child 9: Sometimes your in-between two choices and you don’t know what to do and this is difficult situation</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td>Child 11: They require from us to take decisions but they never teach us how to do that Child 15: It is difficult to think what issues (criteria) to consider so you will do a proper decision</td>
</tr>
</tbody>
</table>

Table 5.11 - Factors affecting children’s decision-making from post-observational interview

- **Post-observational Interviews Main Findings**

From the analysis of the post-observational interviews it can be seen that teachers are an important source of information, but are less important for older children (aged 14-15) as compared with younger children (aged 12-13). Other important sources of information reported included children peers, subject book, the internet, existing projects and modelling. Existing knowledge was identified by children as a factor that influenced their design decisions.

During post-observational interviews children identified a number of evaluation criteria that they used for their design tasks given to them. Attractiveness is still an important criterion but not as important as in pre-observational interviews. Some other criteria reported are time limitations, functionality and strength of their designs. During post-observational interviews children said that they had more opportunities for decision-making as compared with the pre-observational interviews and they identified, materials selection, the appropriate mechanisms or electrical components, the shape and the purpose of their designs as the most frequent design decisions they had to take. Based on the interviews some other issues were identified such as lack of motivation for their design decisions and that children acknowledged the importance of taking decisions in the school environment.

**5.3.2 Children’s Log-books**

Children’s log-books formed an additional source of data in relation to children’s decision-making strategies when designing. In their log-book, each child recorded information about alternative options for their decisions, they justified the decisions taken by them and named any source of information or criteria used to support their decision. Following is an example (Figure
5.1) of a child’s log-book analysis. Any codes from children’s log-books that were relevant to the research questions were highlighted and grouped in concepts in order to summarise the results.

Example of log-book analysis

<table>
<thead>
<tr>
<th>Type of the decision: The type of mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are your options? (Write down the possible options that you have)</td>
</tr>
<tr>
<td>Pulleys or Compound Gears or Bevel Gears (available options)</td>
</tr>
</tbody>
</table>

**Consequences**

- For each option given above explain what will happen if you take this option? And why?
- Pulleys: 1. easy to adjust, because the elastic band can easily be adjust in almost any distance
- 2. not very efficient because of the elastic band might slip from the pulley

**Values**

- How important is the consequence? Why?
- 1. Very important because it will take less time to adjust the mechanism compared to the other options
- 2. Not very important for this project, it might be little slower but is not that important

- Compound Gears: 1. Difficult to adjust because I will need 4 gears.
- 2. Very efficient, because the motion will be transferred with accuracy.

- Bevel Gears: 1. Not very difficult to adjust, not that difficult as compound gears but not that easy as pulleys
- 2. Efficient: much more efficient than pulleys and quite competitive with compound gears
- 3. Good reduction speed, because of the nature of the gears

**(criteria they based their decisions on)**

- 1. Which option is best in the light of the consequences? What are the most important reasons that make you choose that option?
- I decided to use bevel gears because it’s a mechanism that is not very difficult to adjust on my project, is quite efficient and it can give me good reduction speed so my car will have to power to move easily.
- The reasons that made me to decide that mechanism is that the available time for the project is not that long and therefore I shall take risk is I use compound gears. Pulleys are the second best option for my project but I think they will not be very efficient so I didn’t choose it. **(criteria used)**

- 2. From where did you get your ideas? (sources of information)
- I got my ideas mainly from the information given in my textbook, from discussions with my teacher and classmates. I also looked for some information in internet as well. **(sources of information)**

- 3. What are your next steps? How the decision taken will affect your next steps?
- My next step is to decide the size of my car. My decision will affect the size of my car model because of the size of the gears and their efficiency. **(next steps and consequences of the decisions made)**

Figure 5.1 - Example of log-book analysis
5.3.2.1 Results from Children’s Log-books

The data collected from children’s log-books were coded based on the pre-set categories that emerged from the analysis of the pilot studies. Children’s codes were grouped and are presented in categories in the following tables (Table 5.12 – Table 5.15)

- **Children Generate Alternative Choices**

Children generated in their log-books alternative choices for each decision they had to take. The number of alternative choices for each year group was counted and is presented in Table 5.12.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>1 alternative</th>
<th>2 alternatives</th>
<th>3 alternatives</th>
<th>4 alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-13</td>
<td>4</td>
<td>13</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>13-14</td>
<td>1</td>
<td>23</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>14-15</td>
<td>0</td>
<td>26</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5.12 - Number of children’s alternative choices from log-books

- **Evaluation Criteria for Each Option**

Before taking a design decision children asked to specified criteria in order to evaluate their alternative options. Based on those criteria children took their design decisions for their design project. The types of criteria and the frequency used for each age group are presented in Table 5.13.

<table>
<thead>
<tr>
<th>Evaluation Criteria (N=110)</th>
<th>Age Group</th>
<th>Frequency Used (N=37)</th>
<th>Codes from Children’s Log-Books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness (N=56)</td>
<td>12-13</td>
<td>24</td>
<td>Child 12: I think that this idea was looking better than the others so I decided to choose it</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>18</td>
<td>Child 54: The shape of gears is so impressive, the car model look so nice with them</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>14</td>
<td>Child 81: The appearance of the outcome will look better if I choose to use plastic instead of wooden cover</td>
</tr>
<tr>
<td>Time limitations (N=32)</td>
<td>12-13</td>
<td>6</td>
<td>Child 18: Although I wanted to make a solar boat model, I am afraid that there is a possibility to be difficult and I shall not finish the solar boat on time and because of that I decided to make a car model instead</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>14</td>
<td>Child 62: If I use gears, I need to be very accurate and the adjustments may need more time than use pulleys</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>12</td>
<td>Child 101: Because I want to make sure that I shall finish my project on time I shall do the alarm system</td>
</tr>
<tr>
<td>Cost for design projects</td>
<td>12-13</td>
<td>7</td>
<td>Child 7: The cost of photovoltaic cells is high and therefore I shall make a car model using batteries</td>
</tr>
</tbody>
</table>
Table 5. 13- Children's evaluation criteria from log-books

<table>
<thead>
<tr>
<th>(N=19)</th>
<th>13-14</th>
<th>14-15</th>
<th>instead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 41</td>
<td>6</td>
<td></td>
<td>Gears are more expensive than pulleys, which is another reason that made me decide to make my project with pulleys</td>
</tr>
<tr>
<td>Child 87</td>
<td>6</td>
<td></td>
<td>The cost of the electrical components is more or less the same (transistor or thyristor) so it doesn't matter which one to choose in relation to cost</td>
</tr>
</tbody>
</table>

Functionality (N=55)

<table>
<thead>
<tr>
<th>(N=55)</th>
<th>12-13</th>
<th>13-14</th>
<th>14-15</th>
<th>instead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 19</td>
<td>13</td>
<td>19</td>
<td>23</td>
<td>I shall make a boat model that will work with the wind power since this will work better compare to other energy sources</td>
</tr>
<tr>
<td>Child 48</td>
<td></td>
<td></td>
<td></td>
<td>I shall use the gears because the movement is transfer more efficient compare to pulleys</td>
</tr>
<tr>
<td>Child 79</td>
<td></td>
<td></td>
<td></td>
<td>I decided to use thyristor instead of transistor because it suits better the of purpose of my design</td>
</tr>
</tbody>
</table>

Easy to make (N=28)

<table>
<thead>
<tr>
<th>(N=28)</th>
<th>12-13</th>
<th>13-14</th>
<th>14-15</th>
<th>instead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 1</td>
<td>13</td>
<td>9</td>
<td>6</td>
<td>I decided to make a small wind fan because it is easy to make it compared to other designs</td>
</tr>
<tr>
<td>Child 42</td>
<td></td>
<td></td>
<td></td>
<td>I decided to use pulleys as mechanisms because it is easier to adjust them and therefore is more safe than use gears</td>
</tr>
<tr>
<td>Child 84</td>
<td></td>
<td></td>
<td></td>
<td>Whatever I choose I think it will be the same difficulty to make it</td>
</tr>
</tbody>
</table>

Available Materials (N=30)

<table>
<thead>
<tr>
<th>(N=30)</th>
<th>12-13</th>
<th>13-14</th>
<th>14-15</th>
<th>instead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 27</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>I will not use photovoltaic cells since there are not available in our workshop</td>
</tr>
<tr>
<td>Child 67</td>
<td></td>
<td></td>
<td></td>
<td>I shall make my car model using the available materials of the workshop</td>
</tr>
<tr>
<td>Child 93</td>
<td></td>
<td></td>
<td></td>
<td>There was more printed circuit board (PCB) available for transistors and therefore I decided to use one of those</td>
</tr>
</tbody>
</table>

Personal Interests (N=28)

<table>
<thead>
<tr>
<th>(N=28)</th>
<th>12-13</th>
<th>13-14</th>
<th>14-15</th>
<th>instead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 16</td>
<td>9</td>
<td>8</td>
<td>11</td>
<td>I decided to make a car model because I like cars and I am big fun of rallies</td>
</tr>
<tr>
<td>Child 40</td>
<td></td>
<td></td>
<td></td>
<td>Because I like the speed I decided to use gears instead of pulleys, and I hope that the car will be fast enough</td>
</tr>
<tr>
<td>Child 79</td>
<td></td>
<td></td>
<td></td>
<td>I like electronics systems and I decided to make alarm system for my personal use</td>
</tr>
</tbody>
</table>

- Sources of Information
Children reported various sources of information in their log-books. They used the sources of information in order to improve their theoretical knowledge before taking a certain design decision. The sources of information and the frequency used for each age group are shown in Table 5.14.
<table>
<thead>
<tr>
<th>Source of Information (N=110)</th>
<th>Age Group</th>
<th>Frequency Used (N=37)</th>
<th>Codes From Children’s Log-Books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher (N=61)</td>
<td>12-13</td>
<td>23</td>
<td>Child 25: The guidelines given by the teacher help me take that decision</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>20</td>
<td>Child 45: I decided to use gears after a short discussion with my teacher</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>18</td>
<td>Child 79: The teacher lessons help me decide the appropriate electrical components to use</td>
</tr>
<tr>
<td>Subject Book (N=45)</td>
<td>12-13</td>
<td>13</td>
<td>Child 21: The book was useful source of information</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>15</td>
<td>Child 43: I compare possible mechanisms from some examples given in the book</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>17</td>
<td>Child 80: The book included some information about the technical part of my project</td>
</tr>
<tr>
<td>Internet (N=57)</td>
<td>12-13</td>
<td>17</td>
<td>Child 12: I look in the internet to find information</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>19</td>
<td>Child 39: I found some relevant information on internet</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>21</td>
<td>Child 95: I search in the internet to find some information about the electrical components</td>
</tr>
<tr>
<td>Peers (N=50)</td>
<td>12-13</td>
<td>13</td>
<td>Child 35: Because most of the boys in my class will design a car model, I decided to make one for myself as well</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>18</td>
<td>Child 68: I was not sure, and I decided to use pulleys because most of my friends will use them as well</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>19</td>
<td>Child 104: I discuss my ideas with my friends and we decided that it will be nice to design and make an alarm system</td>
</tr>
<tr>
<td>Trial and error – Modelling (N=7)</td>
<td>12-13</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>1</td>
<td>Child 66: I made some trials with the mechanisms and then I decided that pulleys will be better for my project</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>6</td>
<td>Child 75: Before taking a decision I tried to simulate the circuit with different components and using crocodile clips and then I took my final decisions</td>
</tr>
<tr>
<td>Existing projects (N=36)</td>
<td>12-13</td>
<td>13</td>
<td>Child 24: After I explore one of the previous years projects, I decided to do a similar shape with that project because I found it very attractive</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>11</td>
<td>Child 38: I saw something similar in an existing project in the workshop</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>12</td>
<td>Child 74: After a short research in the workshop, I found some existing projects from past years and I decided to do a similar design because was very interesting</td>
</tr>
<tr>
<td>Existing knowledge (N=38)</td>
<td>12-13</td>
<td>11</td>
<td>Child 7: Well, I didn’t search for any information to take my decision, it just came to my mind</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>12</td>
<td>Child 51: I just decided to use pulleys, I think is better</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>15</td>
<td>Child 79: It just came this idea to my mind without any information from other sources</td>
</tr>
<tr>
<td>Television (N=2)</td>
<td>12-13</td>
<td>2</td>
<td>Child 15: I used some of my favourite TV cartoons</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5.14 - Sources of information from children’s log-books
• **Decision will affect forthcoming decisions**

Children were asked to write in their log-books if the decision they already took for their project would affect any decisions they would have to take for their projects. Children’s responses and the frequency for each age group are shown in Table 5.15.

<table>
<thead>
<tr>
<th>Type of Decision (N=110)</th>
<th>Age Group</th>
<th>Frequency Used (N=37)</th>
<th>Codes from children’s log-books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision already taken <strong>will not affect</strong> next decisions (N= 74)</td>
<td>12-13</td>
<td>29</td>
<td>Child 10: This decision will not affect any others decisions</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>27</td>
<td>Child 48: Will not affect any other decision</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>18</td>
<td>Child 82: I don’t think this will decision will affect any other forthcoming decisions</td>
</tr>
<tr>
<td>Decision already taken <strong>will affect</strong> next decisions (N=36)</td>
<td>12-13</td>
<td>8</td>
<td>Child 23: Might affect the type of resistant materials that I shall use to make it</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>9</td>
<td>Child 44: This choice will affect the way I shall design the shape of my project</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>19</td>
<td>Child 75: This decision will affect the other electrical components I shall use later on</td>
</tr>
</tbody>
</table>

Table 5.15- Children’s responses if decision will or will not affect forthcoming decisions from log-books

• **Log-books Main Findings**

From the results of the log-books it can be seen that children specified evaluation criteria such as attractiveness, time limitations, available materials, their personal interests and how easy it was to make the product. Children in their log-books specified sources of information very similar to the sources specified earlier in their interviews. Teachers, peers, the internet, subject books, existing projects and their existing knowledge are the most frequent sources identified. The majority of children reported in their log-books that a design decision taken in their project will not have an effect in the decisions that will follow in the same project.

**5.3.3 Children’s Observations**

Observations enabled the researcher to describe existing situations during the designing of children’s projects in the class environment. In order to improve the accuracy of the data collected, two individual teachers (of the same school) reported their observations on the behaviour of children during design and technology teaching. The completed observation protocols of the two teachers were compared for 20% (5 observations) of the sample. From the comparison, 78% of the responses were identical which is considered to be a high correlation and makes the researcher confident about the outcomes of observations.
The observations were split in 9 time intervals of 5 minutes in a total teaching period of 45 minutes. For each interval the observer reported children’s sources of information used, the types of criteria they used, classroom activities (e.g. lecture, hand on activities etc.) and the children engagement in decision-making activities. Observers also reported the type of design decisions, children strategies and the difficulties that children faced during the decision-making process. The notes of the observation were coded and grouped into meaningful concepts as shown in the following example (Figure 5.2).

Figure 5.2 - Observation analysis sample
5.3.3.1 Results from Children Observations

The data collected from observation protocols were coded like the example of Figure 5.2 and the values were entered into SPSS software for further analysis. The results of the observations are presented in Table 5.15 to Table 5.22.

- **Classroom Activities**

During the observation the observer reported for each 5 minute interval the type of activity that was taking place during the design and technology lesson. The frequencies of the classroom activities for each year group are shown in Table 5.16. Figure 5.3 presents the classroom activities for each year group in graphical form.

<table>
<thead>
<tr>
<th>Class Activities</th>
<th>Age Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-13</td>
<td>13-14</td>
</tr>
<tr>
<td>Lecture</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Lecture/Discussion</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Teacher Circulating</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Teacher Demonstrating</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Seated Work</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Class Discussion</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Hands On</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Small Group</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 5.16 - Classroom activities for each year group from observations

![Figure 5.3 - Classroom activities for each year group from observations](image-url)
Teacher and Children Interactions Observed

The classroom activities observed as presented in Table 5.16 were further analysed for each five minute time interval according to teacher - children interaction and was designated either 'teacher predominantly in control' or 'teacher and children equally in control' and 'children predominantly in control' such as Stables (1995) study. In the 'teacher predominantly in control' group, activities such as lectures and teacher demonstrating were included. In the 'teacher and children equally in control' group activities such as lectures/discussion, teacher circulating and class discussion were included. In the 'children predominantly in control' group, activities such as seated work, hands on and small groups were included. Figure 5.4 indicates the proportion of intervals falling into each category, and how these proportions shifted across the length of the project.

Figure 5.4 - The balance of control between teacher and children
• **Children’s Engagement in Decision-Making Activities**

The children’s engagement in decision-making activities during the lesson was reported during the observation. Children’s engagement was classified in three categories, low, moderate and high. The results for each year group are presented in Table 5.17. Figure 5.5 is presenting the children’s engagement for each year group in graphical form.

<table>
<thead>
<tr>
<th>Children’s Engagement</th>
<th>Age Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-13</td>
<td>13-14</td>
</tr>
<tr>
<td>Low</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Moderate</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>High</td>
<td>32</td>
<td>34</td>
</tr>
</tbody>
</table>

Table 5.17– Children’s engagement in decision-making activities from observations

![Bar chart showing children's engagement for each year group from observations](chart.png)

Figure 5.5 - Children’s engagement for each year group from observations
• **Sources of Information**

During the lesson children were free to access any sources of information that might help them to take a design decision. Observers reported the sources of information that the children used during their design task. The results for each year group are shown in Table 5.18. Figure 5.6 presents the sources of information for each year group in graphical form.

<table>
<thead>
<tr>
<th>Sources of Information</th>
<th>Age Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-13</td>
<td>13-14</td>
</tr>
<tr>
<td>Teacher</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Subject Book</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Internet</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Existing Projects</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Peers</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Additional Book</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Existing Knowledge</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Trial and Error</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 5.18 – Sources of information from the observations

Figure 5.6 - Sources of information for each year group from observations
• **Types of Criteria**

Children used a number of criteria in order to base their design decisions. During the observation the observer reported the types of criteria that were evident from children. Table 5.19 presents the frequencies of each type of criterion for each year group. Figure 5.7 presents the types of criteria for each year group in graphical form.

<table>
<thead>
<tr>
<th>Types of Criteria</th>
<th>Age Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-13</td>
<td>13-14</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Time Limitations</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Functionality</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Cost</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Strength</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Ergonomic</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Availability</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 5.19 – Children’s types of criteria from observations

Figure 5.7 - Types of criteria for each year group from observations
• **Types of Design Decisions**

After completing the observation protocol the observer reported if the design decisions were mainly driven by the teacher or by children, if the type of decision was derived from the curriculum, if the project linked knowledge to meaningful, real-world contexts and if the lesson included decision-making opportunities for children. For each of those categories the observer specified the degree to which was apparent during the lesson. The results are shown in Table 5.20.

<table>
<thead>
<tr>
<th>Type of Design Decisions (Complete after the Observation) (N=24)</th>
<th>Not Apparent</th>
<th>Somewhat Apparent</th>
<th>Definitely Apparent</th>
</tr>
</thead>
<tbody>
<tr>
<td>The design decisions were mainly driven by the teacher.</td>
<td>6</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>The design decisions were mainly taken by children.</td>
<td>1</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>The lesson included decision-making opportunities for children.</td>
<td>0</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>The project linked knowledge to meaningful, real-world contexts.</td>
<td>4</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>The activities derive from the project curriculum.</td>
<td>0</td>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 5.20 -Types of design decisions from the observation

• **Decision-Making Strategies Observed**

The observers reported any decision-making strategies that the children used during their design task in the class. Some strategies observed include values or interest based decisions, or using prior experiences or choosing based only on the most important criterion. The children’s decision-making strategies reported by the observers are summarised in Table 5.21.
Table 5.21 - Decision-making strategies observed

<table>
<thead>
<tr>
<th>Strategies Observed</th>
<th>Frequency Observed</th>
<th>Codes from Observers notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose using personal values/interests</td>
<td>8</td>
<td>Observation 3: Children use their personal values or interests in their decisions mainly for the shape and the appearance of their designs</td>
</tr>
<tr>
<td>Choose based on prior experience (heuristics)</td>
<td>14</td>
<td>Observation 16: Children do not look for any kind of information or set criteria but were using their prior knowledge to take a decision</td>
</tr>
<tr>
<td>Choose based on the most important criterion (Heuristics)</td>
<td>12</td>
<td>Observation 9: Children discussed their criteria in small groups and they tend to decide only based on the criterion/issue they believe is more important</td>
</tr>
<tr>
<td>Older (14-15) children take quicker decisions than younger children (12-13)</td>
<td>7</td>
<td>Observation 21: Children in this class (age 14-15) take quicker decisions than younger children observed (aged 12-13)</td>
</tr>
<tr>
<td>Older Children (14-15) use fewer sources of information decision than younger children (12-13)</td>
<td>5</td>
<td>Observation 18: Children in third class (aged 14-15) use fewer sources of information before taking a design decision that children in first class (aged 12-13)</td>
</tr>
</tbody>
</table>

Table 5.22 - Decision-making difficulties observed

- **Difficulties Observed**

During the observation a number of difficulties that children faced when taking a design decision were reported. Some difficulties observed included the inability to search relevant information, difficulty of setting appropriate evaluation criteria and lack of motivation. The main outcomes from observed children’s decision-making difficulties are presented in Table 5.22.

<table>
<thead>
<tr>
<th>Difficulties Observed</th>
<th>Frequency Observed</th>
<th>Codes from Observers notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty in searching for relevant information</td>
<td>10</td>
<td>Observation 23: Children when asked to search for relevant information to improve their knowledge before taking a design decision presented difficulty in doing it</td>
</tr>
<tr>
<td>Difficulty in setting appropriate criteria</td>
<td>12</td>
<td>Observation 7: when children were discussing the criteria that they will use to take a decision they indicated difficulties and they mainly based their decisions on what they found more attractive</td>
</tr>
<tr>
<td>Lack of motivation in decision-making</td>
<td>9</td>
<td>Observation 17: Children indicated lack of motivation when taking some of the decisions</td>
</tr>
<tr>
<td>Curriculum limitations to give opportunities for meaningful decision-making</td>
<td>6</td>
<td>Observation 22: The tasks was driven by the curriculum and didn’t offer the flexibility to the teacher to give children a task more meaningful to them</td>
</tr>
<tr>
<td>Children don’t want to spend time designing and thinking, they rush in the making part</td>
<td>13</td>
<td>Observation 15: Children don’t want to spent time designing and taking design decisions after thinking, they rush into the making part</td>
</tr>
</tbody>
</table>
• **Observations Main Findings**

From the analysis of observations it can be seen that during the study various classroom activities were taking place; the most frequent activities reported were children working with hands-on activities and working in small groups. From Figure 5.4 it can be observed that design decisions in design and technology education were taken frequently based on interactions between teachers and children. The sources of information as observed were similar to those identified earlier with children’s interviews and log-books, such as teachers, peers, the internet, existing projects and existing knowledge. Trials and other explorative activities were observed to be used as sources of information in many cases.

During observations children reported being worried about the available time they had to finish their design projects. Time limitations were not such important issues during children’s interviews as presented earlier in this chapter. In addition to time limitations, functionality and attractiveness were reported as the most important criteria as observed. Heuristics approaches were observed to take place during children’s design decision-making. Data from observations identified difficulties in decision-making such as setting evaluation criteria, or searching for relevant information and lack of motivation.

**5.3.4 Pre-tests and Post-test**

Pre-test and post-test serve as an additional source of data, with tasks that are not directly related with design and technology activities. The aim was to explore how children handle personal and other decisions and if they use the same strategies as they do in designing activities. An example of the analysis of pre- and post-tests is given in Figure 5.8. The results of pre-test and post-test are presented in the following tables (Table 5.23 – Table 5.28).
Example of Pre-test and Post-test analysis

<table>
<thead>
<tr>
<th>Task 1</th>
<th>Criteria</th>
<th>Hirokitia</th>
<th>Zygi</th>
<th>Sotira</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance from built-up areas</td>
<td>4 Km</td>
<td>2 Km</td>
<td>5 Km</td>
</tr>
<tr>
<td></td>
<td>Cost of the construction</td>
<td>£200 000</td>
<td>£210 000</td>
<td>£180 000</td>
</tr>
<tr>
<td></td>
<td>Distance from the sea</td>
<td>3Km</td>
<td>1Km</td>
<td>4 Km</td>
</tr>
</tbody>
</table>

If you were a government consultant, which location would you recommend for building the station? Explain your thought.

I will choose Hirokitia because it is in between all the criteria and does not have the worst value of any one of the criteria. (Reason for choosing)

Is there any additional information that might help you to take (or improve) the decision? Where will you search to find it?

I would like to know if there are any environmental factors that are important to consider. I shall search for information on the internet and maybe I shall ask some experts in that area. (Sources of information – internet, experts)

Explain how you use the criteria listed in the table? Do you think that all of them are equally important?

I believe that the criteria are not equally important. In my opinion the distance from the built-up areas is the most important criterion, since the health of the people that live close to the station might be affected. The building cost is the second most important criterion and then the distance from the sea. (most importance of criterion – distance from built-up areas)

5.3.4.1 Task 1 – Choosing the Place to build an Electric Power Station

Task 1 required the children to select the best place according to their opinion in order to build a new power station. A table was given (see the example above Figure 5.8) to them providing information of the cost of the station, the distance from built-up areas and from the sea.

Children’s responses on their choice and the reasons for their choice, their possible sources of information and the importance of each criterion were reported to the pre-tests and post-tests.

- Reasons for Taking a decision

Children chose one of the three available locations based on the information given to them. The reasons given by children were grouped both for the pre-test and for the post-test and are presented in Table 5.23 for each year group.
<table>
<thead>
<tr>
<th>Reason given from Children</th>
<th>Age Group</th>
<th>Frequency Used (N=36)</th>
<th>Codes from children pre and post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Choosing based only on the most important criterion</td>
<td>12-13</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Choosing based on the two most important criteria</td>
<td>12-13</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Choosing regarding all criteria as equally important</td>
<td>12-13</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5.23 - Reasons for choosing a location for the power station from pre-test and post-tests
• **Sources of information**

Children reported on their pre and post-test the sources of information that they are likely to use in order to improve their understanding before taking a decision on the place to build the power station. Children’s responses for each year group are presented in Table 5.24.

<table>
<thead>
<tr>
<th>Sources of information</th>
<th>Age Group</th>
<th>Frequency Used</th>
<th>Codes from children pre and post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Experts</strong></td>
<td>12-13</td>
<td>11</td>
<td>Child 22: I can get some information from people that they know more on that issue</td>
</tr>
<tr>
<td>(Pre-test N=41)</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>(Post-test N=44)</td>
<td>13-14</td>
<td>14</td>
<td>Child 46: I shall ask the opinion of experts on that area</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>16</td>
<td>Child 94: the best place to look for information is from content experts</td>
</tr>
<tr>
<td><strong>Internet</strong></td>
<td>12-13</td>
<td>20</td>
<td>Child 8: I shall search the internet to get information about that issues</td>
</tr>
<tr>
<td>(Pre-test N=42)</td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>(Post-test N=47)</td>
<td>13-14</td>
<td>16</td>
<td>Child 49: I shall use the internet because is the easiest source of information</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>6</td>
<td>Child 97: I shall find information in internet</td>
</tr>
<tr>
<td><strong>Existing projects in other areas</strong></td>
<td>12-13</td>
<td>5</td>
<td>Child 30: Maybe the example of previous projects will give me useful information</td>
</tr>
<tr>
<td>(Pre-test N=15)</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>(Post-test N=17)</td>
<td>13-14</td>
<td>6</td>
<td>Child 65: Some other power station build before will provide us with further information</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>4</td>
<td>Child 105: Other similar projects in other areas will be good source of information</td>
</tr>
</tbody>
</table>

Table 5.24 – Sources of information from pre-test and post-tests

• **Importance of criteria**

Children reported in their pre- and post-test the most important criterion for taking their decision. Children used as criterion to take their design decisions mainly the criterion that they considered as the most important. Based on that they concluded which is the best option. The frequency for each criterion used from children is presented in Table 5.25.
Most Important Criterion | Age Group | Frequency Used | Codes from children pre and post tests
--- | --- | --- | ---
Distance from built up areas | 12-13 | 22 | Child 18: I believe that distance from built up areas is the most important criterion since the people that leave close to the station might developed problems
 | 13-14 | 21 | Child 40: The most important criterion is to be as further from built up areas as possible
 | 14-15 | 19 | Child 85: The distance from built-up areas is more important from the others since might create health problems to people around the station
(Pre-test N=62) (Post-test N=61)

Distance from the sea | 12-13 | 10 | Child 13: The distance from the sea is the most important criterion
 | 13-14 | 8 | Child 54: The distance from the sea is important for the proper function of the station
 | 14-15 | 7 | Child 96: The most important criterion is the distance from the sea, the closer the better
(Pre-test N=25) (Post-test N=27)

Building cost | 12-13 | 4 | Child 23: The cost of the station is very important criterion
 | 13-14 | 5 | Child 64: I believe that the construction cost is the most important criterion
 | 14-15 | 6 | Child 102: The cost is more important criterion than the other two
(Pre-test N=15) (Post-test N=13)

Criteria equally important | 12-13 | 0 | 
 | 13-14 | 2 | Child 56: I think that all criteria are very important
(Pre-test N=6) (Post-test N=7) | 4-15 | 4 | Child 101: I believe that all criteria are equally important

Table 5.25 - Importance of criteria from pre and post tests

5.3.4.2 Task 2 – Choosing a Mobile Phone

Task 2 required from children to select one of the three mobile phones proposed to them. For each mobile phone a picture was given to children with information about the cost and some technical features of the phone. Children reported their choice giving reasons for it, and named the possible sources of information and evaluation criteria that they will use to take a decision. Following in Figure 5.9 is an example of the analysis of Task 2.
What would you do if you were in Marias place? Explain your through

I will choose the first mobile phone (Nokia N81) because I like Its appearance and because suits my needs with its technical features. (Reason for choosing)

Are there any additional information that might help you to take (or improve) the decision? Where will you search to find it?

If I need any further information I will search through the Internet and maybe I will visit some shops and ask the opinion of the people selling them (Sources of information)

Explain how you use the criteria listed in the table. Do you think that all of them are equally important?

I believe that the criteria are not equally important, the cost and the appearance of the phone are very important for me. I took my decisions mainly with those two criteria. (criteria)

Figure 5.9 – Example of pre and post-test analysis for task 2

- **Reasons for Taking a Decision**

Children chose one of the three available phones and gave reasons for taking that decision. The reasons were grouped both for the pre-tests and for the post-tests and are presented for each year group in Table 5.26.
### Reason given from Children

<table>
<thead>
<tr>
<th>Reason given from Children</th>
<th>Age Group</th>
<th>Frequency Used</th>
<th>Codes from children pre and post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>The more Attractive</td>
<td>12-13</td>
<td>18</td>
<td>Child 25: I shall buy the Nokia phone because it is more attractive than the other two</td>
</tr>
<tr>
<td>(Pre-test N=42)</td>
<td>13-14</td>
<td>17</td>
<td>Child 68: I chose the second mobile phone because I like it more than the others</td>
</tr>
<tr>
<td>(Post-test N=43)</td>
<td>14-15</td>
<td>7</td>
<td>Child 84: I shall choose the first phone because it looks more attractive than the other two phones</td>
</tr>
<tr>
<td>The Cheapest</td>
<td>12-13</td>
<td>13</td>
<td>Child 11: I shall go for the cheapest of the three phones</td>
</tr>
<tr>
<td>(Pre-test N=39)</td>
<td>13-14</td>
<td>17</td>
<td>Child 60: I choose mobile number 3 because it is cheaper than the others</td>
</tr>
<tr>
<td>(Post-test N=37)</td>
<td>14-15</td>
<td>9</td>
<td>Child 94: I shall choose the third phone because it has all necessary features and is cheaper than the other two</td>
</tr>
<tr>
<td>The best in technical features</td>
<td>12-13</td>
<td>13</td>
<td>Child 19: My decision is to take the first phone because it has better memory</td>
</tr>
<tr>
<td>(camera, memory, screen, battery)</td>
<td>13-14</td>
<td>16</td>
<td>Child 43: I chose the second phone because it has better memory</td>
</tr>
<tr>
<td>(Pre-test N=49)</td>
<td>14-15</td>
<td>20</td>
<td>Child 82: The first mobile has bigger memory than the other two so it suits my needs better</td>
</tr>
<tr>
<td>(Post-test N=54)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In between</td>
<td>12-13</td>
<td>7</td>
<td>Child 24: Phone one combines good price, nice appearance and good technical features</td>
</tr>
<tr>
<td>(consider all criteria and decided based on all of them)</td>
<td>13-14</td>
<td>8</td>
<td>Child 67: My choice is phone one because from my point of view combines all the criteria well</td>
</tr>
<tr>
<td>(Pre-test N=29)</td>
<td>14-15</td>
<td>14</td>
<td>Child 97: Phone one is the best choice because it has good technical characteristics and don’t have the worst value to any of the criteria</td>
</tr>
<tr>
<td>(Post-test N=33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific brand name</td>
<td>12-13</td>
<td>5</td>
<td>Child 3: I shall choose the Sony ericsson phone because it the brand name that I like most</td>
</tr>
<tr>
<td>(Pre-test N=10)</td>
<td>13-14</td>
<td>3</td>
<td>Child 52: Phone one is the brand name that I always trust</td>
</tr>
<tr>
<td>(Post-test N=8)</td>
<td>14-15</td>
<td>2</td>
<td>Child 93: I shall choose the Nokia mobile phone because this brand name is the one that I always buy</td>
</tr>
</tbody>
</table>

Table 5. 26– Reasons for choosing a mobile phone from pre-test and post-tests
Sources of information

When completing the pre- and post-tests children reported the sources of information that they would use before taking a decision. Their responses for each age group are presented in Table 5.27.

<table>
<thead>
<tr>
<th>Sources of information</th>
<th>Age Group</th>
<th>Frequency Used</th>
<th>Codes from children pre and post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td></td>
<td>12-13</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Market Research</td>
<td>13-14</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>(Pre-test N=59)</td>
<td>14-15</td>
<td>21</td>
<td>25</td>
</tr>
<tr>
<td>(Post-test N=67)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peers (Pre-test N=46)</td>
<td>12-13</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>(Post-test N=48)</td>
<td>13-14</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Content Experts</td>
<td>12-13</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>(Pre-test N=17)</td>
<td>13-14</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>(Post-test N=18)</td>
<td>14-15</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Internet (Pre-test N=59)</td>
<td>12-13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>(Post-test N=65)</td>
<td>13-14</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>24</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 5.27– Sources of information from pre-test and post-tests

Importance of criteria

In their pre- and post-tests children specified the most important criteria for their decisions. The frequency of each criterion is shown in Table 5.28.
Chapter 5: Main Study Results

### Most Important Criterion

<table>
<thead>
<tr>
<th>Most Important Criterion</th>
<th>Age Group</th>
<th>Frequency Used</th>
<th>Codes from children pre and post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>12-13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Cost</td>
<td>12-13</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Technical Features</td>
<td>12-13</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>14-15</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 5.28 - Importance of each criterion from pre-test and post-tests

- **Pre-test and Post-test Main Findings**

Pre-tests and post-tests identified decision-making behaviour with activities that were not directly related with design and technology education. From the analysis of the results it can be seen that the differences of children’s responses from pre-test responses to post-test were very small. Older children (aged 14-15) were slightly more able than younger children (aged 12-13) to improve their post-test score as compared to their pre-test. From the results it can be seen that children were more able to handle multiple evaluation criteria when taking more personal decision (e.g. buy a mobile phone) or when the decision was more meaningful to them as compared to the design decisions taken for their design tasks. Many of children’s decisions as reported in the pre-tests and post-tests were value based. The sources of information reported included market research, peers, internet and content experts. The evaluation criteria identified for the task given to them were the attractiveness, the cost and the technical features.
Summary
The results were analysed using standard qualitative research methods indicating repeated codes from children's responses and numerical values in some cases when this was appropriate. Data includes pre- and post- observational interviews, children’s log-books, observations and pre- and post- tests. From the analysis of the data collected a number of research outcomes emerged and these are presented in tables and figures. The analysis was made for each age group separately in order to enable comparisons between the age groups. The results indicated the main sources of information that children used for their design decisions, the degree to which they used evaluation criteria for their decisions, the type of decision-making opportunities that teachers offered to children, information on the possible ability of children to transfer decision-making skill from design and technology activities to other areas of life, possible difficulties that children faced during decision-making and how children handled personal decisions against design decisions in classroom. The analysis of the results will be presented in Chapter 6 (analysis of the results) and will be discussed and related with literature reviewed in Chapter 7 (discussions).
Chapter 6: Analysis of Results

Overview: This chapter is presenting the strategies that were used in order to analyse and discuss the results. Validity, reliability and triangulation of the research data results will be addressed in relation to the research procedures undertaken in order to ensure them. The different type of data collected for each research question will also be analysed and their relationship to the triangulation of the data will be discussed.

6.1 Data Collected for Each Research Question

During the design of the research study a variety of data collection sources were planed to be used in order to triangulate the results of the study. The research questions of the study (RQ) remained unchanged and are as follows:

<table>
<thead>
<tr>
<th>RQ</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>What types of decisions do teachers expect secondary education students (12-15 years old) to engage in during different parts of designing and making?</td>
</tr>
<tr>
<td>RQ1a</td>
<td>What decision-making opportunities are included in design and technology curricula?</td>
</tr>
<tr>
<td>RQ1b</td>
<td>What decision-making opportunities do teachers give to children when working on design and technology activities?</td>
</tr>
<tr>
<td>RQ2</td>
<td>What strategies do secondary education pupils’ follow in order to make their design choices?</td>
</tr>
<tr>
<td>RQ2a</td>
<td>What types of sources of information do secondary education students prefer when making a technological decision?</td>
</tr>
<tr>
<td>RQ2b</td>
<td>What types of sources of information do secondary education students prefer when making a technological decision?</td>
</tr>
<tr>
<td>RQ3</td>
<td>What are the difficulties that secondary education pupils’ face in their efforts to make decisions in their designs?</td>
</tr>
<tr>
<td>RQ3a</td>
<td>What is the ability of students to develop criteria for evaluating options?</td>
</tr>
<tr>
<td>RQ3b</td>
<td>Does the evaluation criteria change as the children grow older?</td>
</tr>
<tr>
<td>RQ4</td>
<td>To what extent can decision-making skills learnt within the area of design and technology be transferred to other activities?</td>
</tr>
<tr>
<td>RQ4a</td>
<td>Does experience in design and technology improve the children’s capabilities in making decisions in other situations such as personal/social dilemmas (like environmental issues, personal/public purchasing, genetic engineering, biotechnology etc.)?</td>
</tr>
<tr>
<td>RQ4b</td>
<td>Are children more able to transfer decision-making skills in personal/social dilemmas as they grow older?</td>
</tr>
</tbody>
</table>

Table 6.1 - Research questions of the study
The data collection methods that were designed to give information for each research question were presented earlier in Chapter 3 (Table 3.3). Based on this design and in order to improve the quality of measurements, for each research question (RQ) data were collected from various sources. Data collection tools used included literature review, review of curricula and books, interviews with teachers and children, observations of children, children’s work in log-books work, pre-tests and post-tests. The research questions were examined in relation to those data collection tools in order to triangulate the research outcomes. The specific data collection for each research question of the study is presented in Table 6.2.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Literature Review</th>
<th>Teacher Interviews</th>
<th>Curriculum/Books</th>
<th>Children Interviews</th>
<th>Observations</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Children's Folders</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 1a</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 1b</td>
<td></td>
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<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 2</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 2a</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 2b</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 3a</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 3b</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RQ 4</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>RQ 4a</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>RQ 4b</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2 - Data collected for each research question

From Table 6.2 it can be seen that for each research question and sub-question there were at least 3 data collection tools that are giving relevant information, and in most cases the RQ are addressed by 6 individual data collection tools. Based on this strategy, the results of the study as obtained from various sources can be related together and the emerging outcomes can be triangulated.
6.2 Triangulation, Validity and Reliability of the Study

In qualitative research the concepts of triangulation, validity and reliability are intertwined. They are treated separately and the discussion starts with triangulation, but inevitably aspects of the subsequent discussions of validity and reliability appear.

Validity and reliability are two factors which any researcher should be concerned about while designing a study, analysing the results and judging the quality of the study. According to Golafshani (2003) in qualitative research, triangulation is usually a strategy that aims to improve the validity and reliability of research or evaluate the findings. Mathison (1988) argues this by saying:

“Triangulation has become an important methodological issue in naturalistic and qualitative approaches to evaluation [in order to] control bias and establishing valid propositions because traditional scientific techniques are incompatible with this alternate epistemology.” (p. 13)

Triangulation is seeing things from different angles and in research there are several types of triangulation that can be applied. Some of the main types of triangulation include data/information triangulation, investigator triangulation and methodological triangulation (Thomas, 2009).

For the purpose of this research the data gathered were triangulated by the use of different sources of data/information. As a result different data collection tools were designed to measure the same research question and sub-questions of the study. In the research 3 different age groups were investigated, and their behaviours in certain decision-making tasks were identified. The research was undertaken with a balanced number of children between the three age groups (36 children of each group), and with a balanced number of boys and girls included in the sample in order to ensure that the results are as representative as possible. The data collection methods were also piloted and the results of the pilot and main studies are very similar.

Another type of triangulation used was the investigator triangulation, which involves using several different investigators/evaluators in an evaluation project. A number of colleagues were used as individual observers during observations. The observers used the same observations
protocols and their responses were correlated together with a correlation of 78%. A number of teachers and content experts (inspectors and academics) gave feedback on the interview, pre-tests and post-tests protocols.

Methodological triangulation was also employed with the use of multiple qualitative and quantitative methods. A combination of qualitative data collection techniques, such as interviews, observations and log-books were collected along with pre-tests and post-tests which contained other qualitative sources of data. This enabled research outcomes to be obtained from different perspectives and gave more evidence of the validity of the results.

Based on the outcomes of the results Chapter as presented in Chapter 5, the multi triangulation methods used in the research improved the validity and the reliability of the results and they enhanced the accuracy of the findings and the quality of the overall research outcomes.

6.2.1 Validity

According to Thomas (2009) validity is the degree to which an instrument such as a test, “measures what it is supposed to be measuring” (p.107). In other words validity for examiners whether a measure is measuring the concept that the researcher thinks is being measured. In qualitative research, (for the improvement of validity) mainly triangulation methods are used. The various sources of data collected through the research study, the use of multiple kinds of triangulation and their comparison with the literature reviewed improved the validity of the data collected. Because the results are coming from different areas, their similarities enhance the study’s validity.

The data collection tools before used in the main study were piloted in an attempt to improve their quality. From the pilot studies information on how to improve the research tools was obtained, which helped to redesign the main studies data collection instruments in such a way as to improve the validity of the study. The interviews and log-books were designed with open-ended questions in a way that leaves teachers and children the freedom to express their own ideas. There was also a participant observation with two independent teachers/researchers observing the same class at the same time. Using those procedures, more than one person was involved in the research and since their field notes were very similar the validity of the measurements were improved.
In addition extensive quotations from field notes, transcripts of interviews, observation protocols, children’s log-books, pre-tests and post-tests were used in an attempt to present as representative results as possible. The results from the different data collection methods were related together in order to improve the quality of the outcomes and the emerging evidence to support the conclusions of the study that will follows.

6.2.2 Reliability

Reliability refers to the degree to which a data collection instrument such as interviews or test will give the same result on different occasions (Thomas, 2009). In other words reliability is the degree to which a measurement procedure produces similar outcomes when it is repeated. The current research, addresses the complexity of decision-making from different point of views, including curriculum materials, teachers’ and children’s perspectives. The data collected from those areas were piloted and slightly modified for the main study. The results of the pilot and the main study were analysed and the outcomes are very similar. This comparison of the pilot and main study results proves the high reliability of the data collection instruments used in the study.

The triangulation methods used for the study (data, investigator and methodological triangulation) also served to improve the reliability of the research outcomes. The positive correlation of the results obtained from the different data collection methods indicates similarities to their outcomes as presented in the previous Chapter (Chapter 5) and which gives evidence for the high reliability of the results.

During the analysis of the study the various data collected were examined systematically. In the case of the interviews multiple listening’s of audio tape by different people and multiple transcripts of the outcomes were made. The observation protocols were exactly the same for all observations and there was stability of the observation protocol and method over time, one observation per week for each class participating to the research. This consistency enables the improvement of the reliability of the data collected.

Additionally samples of the data collected from various sources were double-coded as a means of checking reliability (Miles and Huberman, 1994). In some cases, two or more researchers were coding the same field data especially in observations where two researchers were
observing children while designing their design projects and the observers completed an identical individual observation protocol in parallel.

The data collection instruments were designed with the assistance and feedback of content experts in Cyprus (design and technology inspectors) and England (staff of the Design and Technology Department at Loughborough University). The results were also presented to conferences and in journal papers, and the feedback obtained was used to improve the methods leading to a higher reliability of the instruments.

6.3 Models of Children Decision-Making in Design and Technology

As the research study was investigating different types of data and information, a more detailed representation of the factors that are involved in children’s decision-making in design and technology education was gained. Each new information or research outcome was considered in order to build a model that explains children’s decision-making strategies within a design and technology class. The information and the study’s results were added to the model and as a result the model was growing and modified as the research progressed and new issues were addressed.

The first model was formulated reflecting how design decision-making appeared from the relevant literature reviewed. The results of the pilot studies were then added to the model, including current practice by teachers in defining the national curricula and children perspectives in design decision-making. Following the outcomes of the main research undertaken in Cypriot schools including children’s interviews, observations, children’s log-books and test results which all contributed to the build of the final a model that provided description of how decision-making strategies are followed by children in class.

The discussion of the results in terms of the development of the framework where children design decision-making behaviour is explained is important, because is describing the different factors affecting children’s decision-making and the degree to which each factor is affecting children’s decision-making. Those factors indicate the complexity of the issue of children decision-making, and the difficulty of exploring and explaining such a multifactorial area. The discussion that will follow in the next Chapter will be presented based of this children’s decision-making model that describes decision-making in practice. Analysis of the results in terms of research questions will also be discussed in the following Chapter (Chapter 7).
6.4 Strength and Weaknesses

The strength of the study is the diversity of the data collected and of the way that data were analysed. Different sources of data/information and different type of participants (children, teachers, curriculum etc.) are giving different point of views and the combination of those tools leads to more strong evidence on the authenticity of the outcomes of the study.

The terms validity and reliability are more often discussed in quantitative research methodologies and less frequently used in qualitative research. In qualitative research those terms cannot be a numerical value but can be measured mainly in terms of the triangulation methods used to the study in order to ensure that the outcomes are correct. This is a limitation for qualitative research in general and is not only applied to this study.

The research study gathered data from many sources and this enhanced the richness of the information obtained. All those data build confidence and the validity and reliability of the research outcomes since information is not based only in a single perspective. On the other hand this diversity of the information analysed is somewhat 'lost' or 'smoothed' when the outcomes are aggregated together in order to design a single model that explains children's decision-making. Therefore, mainly results that appeared repetitively from the data gathered were strongly considered for the development of the children's decision-making model, and issues that emerged without support were taken into account with caution.

In research, generalisability is the extent to which research findings can be applied in settings other that the setting in which the original research took place with similar outcomes (Thomas, 2009). In qualitative research because usually the sample is small generalising the outcomes of a study is not usually supported. In that sense, generalisations of the research outcomes for this study are not claimed although the sample of the research is considered to be high for a mainly qualitative study. Therefore the results mainly apply to the specific domain of the Cypriot environment, where the data was collected. Supporting was gathered from teachers’ interviews in England, Cyprus and Iceland is more likely to be more valid in general. Results that support similar conclusions outcomes they are positively related to the outcomes found in other research studies internationally they can also be treated as results that can be applied in general and not only in Cyprus.
Although the results that are specific to the Cypriot domain cannot be generalise to places outside Cyprus this does not necessarily mean that the outcomes will not be similar if similar studies were in other countries. Research in other countries about children's decision-making strategies will be useful in order to give more information about the generalisability (or not) of the research outcomes of this study.

**Summary**

Triangulation methods presented in this Chapter include the use of various data collected, the use of different investigators and the use of different methodological approaches in order to improve the quality of the outcomes. The different methods of triangulation as presented in this Chapter improved the validity and the reliability of the results of the study. This Chapter presents the strategy for the analysis of the results in the way that formulates the basis for their discussion in the next Chapter (Chapter 7).
Chapter 7: Discussions

Overview: This Chapter is discussing the main outcomes of the pilot and the main studies in relation to the literature reviewed. An interpretation of the research outcomes is also presented. From the discussions of this Chapter a model for explaining factors involved in children’s decision-making behaviour in design and technology education was developed. The model is based on the literature reviewed and the results of this study. The Chapter also provides some answers to the research questions in the light of the research findings. Some additional emerging outcomes that have been identified from the analysis of the results are also discussed.

7.1 Emerging Model of Decision-Making

The literature review collected data and information from various disciplines. After the relevant literature had been reviewed and the pilot and the main studies had been analysed, a model was designed that describes the factors that are involved in children’s design decision-making in design and technology education. The purpose of the model is to serve as a guideline tool for the development and the analysis of the factors involved in children’s decision-making behaviour.

7.2 Factors Involved in the Emerging Model of Decision-Making

As a result of the literature reviewed and the findings of the pilot and main studies a number of factors were identified as key elements that are involved in children’s decision-making process in design and technology education. Analysis of the key elements revealed four groups: (1) knowledge – skills – values, (2) teachers’ perspectives, (3) children’s perspectives and (4) curriculum requirements. The following sections discuss those factors as they have emerged from the research.

7.2.1 Knowledge – Skills – Values

From the literature reviewed (Coles and Norman, 2005; Hicks et al, 1982; Norman, 1998; Pedgley, 1999; Trimingham, 2008) it can be concluded that knowledge, skills and values are key factors in decision-making in design and technology. Many decisions taken by children within design and technology classes are based on their existing knowledge, their personal or social values and their skills to work out the best possible choice in order to reach a design decision.
The involvement of knowledge, skills and values in children’s decision-making processes was also evident from the pilot studies conducted. Some children were searching for information to build up their knowledge in order to support their decisions. Evidence for this outcome was found from observations, teachers’ and children’s interviews and from the requirements of the national curricula reviewed (emerged category 6, from Table 4.36). The effects of values were also identified from the outcomes of the pilot studies (emerged category 17, from Table 4.36). Pilot studies identified that in many cases children take their decisions with the effects of values being evident; for example they decide about the topic of their project based on their interests. The involvement of values in design decisions was also identified from previous research studies (Hicks et al, 1982; Coles and Norman, 2005; Trimingham, 2008).

The main study results also identified the involvement of knowledge in decision-making in design and technology education. Children’s interviews before and after the design project identified possible sources of information that children use in order to build their knowledge to support their design decisions (Tables 5.3 and 5.8). For example a child said during the pre-observational interview: “before taking a decision there are things that I will learn in order to improve my knowledge on that subject, there are various places I can look on, books, internet, or ask my teacher”.

In the research study the existence of knowledge based decisions was also evident from the observations (Table 5.18) and from the children’s log-books (Table 5.14). Children were observed to build up their knowledge using various sources of information (books, internet, existing projects, peers etc.) and explained their decision based on the information they learnt. The need for relevant information before taking a decision was also discussed by Clemen (1991) who argued that information is required in order to improve knowledge and as a result to make better decisions.

The results of the study also found that children used their existing knowledge in order to reach a design decision for their design projects. During the observations the researchers noted that very often children did not search for relevant information before taking a decision and they relied on what they already knew from previous projects (Table 5.14). They only searched for additional information when the decision area was completely unknown to them. The use of children’s existing knowledge was also noted in the children’s interviews (Table 5.8), for example a child said during the interview: “if what I have to do in my project is something similar to what I did before, then I will use what I already know to decide about my next steps”. Tannert,
Elvers and Jandrig (2007) also argued that in many cases decision-makers rely on existing knowledge and reflect on any remaining uncertainties. Additionally the use of existing knowledge by children in order to reach a decision was identified from Gilbert (1991) who found that when children face decision-making problems they usually solve the problem by using their empirical knowledge.

Skills that are involved during design decision-making were also identified from the literature reviewed (e.g. Hicks et al, 1982; Norman, 1998; Pedgley, 1999; Trimingham, 2008). In the pilot studies, children demonstrated their skills in order to take a decision based on number of criteria given to them. They were also observed to combine different sources of information with their personal values in order to reach some of their design decisions (emerged category 16, from Table 4.36). The skill of making a judgment in order to weigh the advantages and disadvantages of the available options was also identified from Sadler (2004).

Hicks et al. (1982) discussed the importance of skills in almost every design and technology activity. They identified four categories of skills: investigation, invention, implementation, and evaluation. The findings of the current study are consistent with the guidelines of Hicks et al. (1982), since children were observed to investigate possible options (Table 5.18), invent possible solutions (Table 5.12), implement their decisions (Table 5.21) and evaluate possible options they had and the outcomes of their decisions (Table 5.21). In the current study children’s decisions were affected by the way they set some evaluation criteria in order to support their design decisions. The way that children treated those multiple criteria and which of those they considered to be more important than others were affecting the decisions taken for their project. Those results were evident from all sources of information, children’s interviews (Table 5.9), log-books work (Table 5.13), observations (Table 5.19) and pre-tests and post-tests (Tables 5.23 and 5.28). The existence of skills in decision-making was also supported by other researchers (McCormick, 2004; Newmann, 1990).

The existence of the use of values in design decisions were extensively explored by Trimingham (2008) and Coles and Norman (2005). Additionally many other researchers also identified the role of values in decision-making (Fleming, 1986b; Kolstø, 2001a; Patronis, Potari, and Spiliotopoulou, 1999; Zeidler, Walker, Acket, and Simmons, 2002). The findings of the study show that in many cases children take value-based decisions both for their design projects and for their own personal decisions as well (Tables 5.9, 5.13, 5.19, 5.21 5.23, 5.25 and 5.26).
interview, a child said: “I took my decision mainly based on the product attractiveness, it is important to me for something to be attractive”.

Many of the children's decisions during the pre-test and post-test were mainly value based. From Table 5.25 it can be seen that 62 out of 110 children decided to place the power station as far as possible from built-up areas despite this costing more. The reasons given for taking that decision were mainly because the health of people that stayed near might be affected by the power station and despite the high cost, the power station has to be built as far as possible from built-up areas. Similar responses were identified from children log-books and were reported from the researchers during the observations.

Based on the outcomes of the literature reviewed and the findings of the pilot and the main studies as discussed above it can be concluded that knowledge, skills and values are a group of factors that are involved in children’s decision-making, and therefore those issues are part of the model that explains children’s decision-making in design and technology. Figure 7.1 presents this relationship graphically. The arrows represent the interactions of those factors. Hence any change in one of those factors may influence the others.

![Figure 7.1 - Knowledge, skills and values as factors involved in children decision-making](image)

**7.2.2 Teachers' Perspectives**

The perspectives of the teachers have an important role in the teaching and learning of children (Banks et al., 2004; McCormick, et al., 1994; Nicholl, 2004; Rutland and Barlex, 2008). Especially in an issue such as the development of decision-making capabilities, the opportunities that teachers offer to children to make their own design decisions are significant in how children acquire this skill. From the literature reviewed and the results of the research study, issues such as teachers’ ideas about teaching and learning (Banks et al., 2004); teachers’ beliefs (McCormick et al., 1994), teachers’ implementation of the curriculum and the
teaching resources they have chosen to use (Anning et al., 1996) have important roles in their teaching and therefore guiding children to develop decision-making skills.

**Teachers’ Ideas about Teaching and Learning**

Pajares (1992) argued that teachers’ views of teaching and learning, as well as their beliefs about knowledge and intelligence have an important impact on the way they teach. This statement is also supported from the findings of the study. From the pilot studies teachers showed that their own ideas about teaching and learning are affecting the decision-making tasks that were given to children. For example an English teacher said during the interview: “With younger children, years 7 to 8 (aged 11-13) we structure the projects so that any major decisions – those related to the manufacture of the object – are already stated in the project”. Similar responses were given by teachers from Cyprus and Iceland. The effects of teachers’ own ideas about teaching and learning in children’s decision-making were evident in the emerged categories of the pilot study (emerged category 11, from Table 4.36).

In the main study, the analysis of observation protocols identified the pedagogical methods that teachers used in their classes (Table 5.16) and the student engagement in decision-making activities (Table 5.17). From the results it seems that the learning activities that a teacher employs for the class will affect the interests and the engagement of the children in decision-making. Interviews also identified that children expect more opportunities for decision-making from their teachers and that the approaches that teachers follow in the class are related to the children’s interest and their participation in the class activities. For example a child said during interview: “not all teachers teach the same way, it depends on the teacher to give us opportunities to work independently or to make the lesson more interesting to us”.

Other researchers also identified the important role of teachers’ own ideas in their teaching and learning. Davis and Krajcik (2005) argued that the characteristics of the teachers, such as their knowledge, beliefs, and dispositions towards reflection and improving their own practice will affect the success of the curriculum. In addition, research has indicated that teaching can be influenced by factors such as teachers’ beliefs (McCormick, 1990, p.41); teachers’ pedagogic knowledge (Banks et al., 1999, p.94); problems of curricular choice and coverage (Anning et al., 1996, p.6) and classroom and school administration expectations (Banks et al., 1999, p.90). Teachers own ideas and perceptions were also discussed from Hallam and Ireson (1999) as presented earlier in Chapter 2 (Figure 2.5).
Rutland and Barlex, (2008) also pointed out that the teachers should manage and organise their classroom to ensure that the social and cultural environment is conducive to creative activity. Therefore both the results of the current study and the outcomes of other literature reviewed indicates that teachers’ own ideas and the way they organize their teaching will influence pupils’ learning experience, including the development of decision-making skills.

- Teachers’ Implementation of the Curriculum

Literature reviewed suggested that teachers’ implementation of the curriculum will have an effect on the quality of their teaching. Rutland and Barlex (2008) argued about the importance of classroom and curriculum organisation and management of them by the teacher. The results of the research study also supported this statement. From the pilot study it can be seen that teachers usually gave emphasis to specific issues in the curriculum and as a result the way they implemented the curriculum had an effect on the content of decision-making opportunities that were given to children. Davis and Krajcik (2005) also supported that the effectiveness of the curriculum is deepened by the way teachers employed it. In the pilot studies teachers from Cyprus, England and Iceland expressed the belief that the curricula in their countries included decision-making opportunities, but in practice it is difficult to apply all those decision-making opportunities with children due to many limitations (time, resources and children’s abilities).

The main study results also found that the implementation of the curriculum affected the opportunities that teachers gave to children in taking their design decisions. Observations of teachers while teaching identified that different teaching approach might be used in order to enhance children’s opportunities to take their own design decisions. Table 5.20 shows some indications that teachers were giving projects to children linked to meaningful, real-world contexts and at the same time the activities were appropriately linked to the curriculum. Jones (2003) discussing the development of the curriculum in New Zealand, suggested that real-word examples and meaningful tasks are important issues that the curriculum should include. Based on the literature reviewed and the findings of the pilot and the main study it can be argued that the way teachers implement the curriculum has an effect on the development of children’s decision-making learning opportunities.

- Teachers and Resources

From the review of the literature there is limited empirical work on the role of teaching materials like books, and their actual effect on teaching. Some of the studies suggested that teaching
materials could support teachers both with the content of the subject and with teaching methodologies (Ball and Cohen, 1996). In England the Nuffield scheme as discussed by Givens and Barlex (2001) developed particular pupil design tasks with an emphasis on design in the form of pupils' design decisions. According to Givens and Barlex (2001) the Nuffield project is based on the design and technology curriculum and the pedagogy developed by the Project is widely used in UK.

From the findings of the pilot studies it emerged that teachers believe that most books that were being used in design and technology classes did not include sufficient decision-making opportunities. For example a Cypriot teacher said: “The textbooks that are used for secondary education do not include many opportunities for decision-making” (emerged category 11, from Table 4.36). In the case of Cyprus where specific, compulsory books are used in design and technology education, their role is significant in determining the decision-making opportunities that are offered to the children. Despite the results of the pilot studies not directly supporting the contribution of books and teaching resources to the development of decision-making skills, their role in implementing teaching and learning is significant. This idea is also supported from the literature. For example, Barlex and Rutland, (2003) suggested that an important factor in design and technology education is the nature of the design decisions that the pupils are required to make through the teaching materials and the designing and making of such activities needs to include decision-making opportunities.

- Teachers’ Role in Children’s Decision-Making

Based on the evidence identified from literature reviewed and the pilot and main studies as presented in this section it can be argued that teachers have an important influence on how children develop decision-making strategies in design and technology education. Figure 7.2 presenting these relationships graphically.

![Figure 7.2 - The role of teachers in children's decision-making](image)
7.2.3 Factors Affecting Children’s Decision-Making Process

There are various factors that affect children’s decision-making strategies. Based on the literature reviewed and from the findings of the pilot and the main studies, the most important factors were selected in order to investigate their effects on the processes that children used in order to take a decision. The main factors that were identified from the research were the children’s strategies, their age, the influence from peers, their ability to transfer skills and possible difficulties they face. These factors are discussed in the following sections.

- **Children’s Strategies**

Literature reviewed suggested various strategies that children follow in order to take their decisions (Clemen, 1991; Stanovich and West, 2000). In most cases approaches based on heuristics and other simplified techniques were used by children during decision-making (Gigerenzer, 2001). Nicholl and McLellan (2007a) pointed out that in design and technology stereotypical designs are often used by children. Common shapes and images such as love hearts and footballs are the basis of many of children’s design ideas. Those stereotypical designs that the children presented as an outcome emerged as a result of the strategies that they followed in order to take their design decisions.

Various types of strategies that children follow during their decision-making processes were identified from the pilot studies. Children seemed to search (or not search) for different kinds of information, they treated criteria for their decisions in various ways and they used different strategies in order to reach a decision (emerged category 18, from Table 4.36). The results of the pilot studies suggested that children’s decision-making strategies affected their design decisions.

The main study findings identified more information on strategies that children followed in order to reach their design decisions. The most significant strategies are discussed below:

- **Children consider teachers as an important source of information who they will ask for the information they need (Tables 5.3, 5.8 5.14 and 5.18). This is evident from children’s interviews, observations and their log-books. Some children do not try to find information outside the classroom environment and they tend to ask their teachers. The most likely explanation for this outcome is that the teacher is the source of information that is easier to access, is considered as a reliable source and they directly relate them with the**
assessment criteria of their projects. The findings of the current study are consistent with those of Hamilton (2007) who found that teachers act both as facilitators and resources within the dynamics of the interactional process with children and the teacher can become a significant catalyst for effective learning. Teachers are also seen by children as an important source of information in McCormick (2004) study.

- Children defined a number of criteria to evaluate their alternative options before taking their design decisions (Tables 5.4, 5.6, 5.9, 5.13 and 5.19). This strategy was observed more frequently with older children (aged 14-15) and is less evident in younger children (aged 12-13). In some cases because of the difficulty in handling multiple evaluation criteria, they only based their decision on the criteria that they considered to be most important for them.

- In many cases, children used a number of simplified techniques, such as trial and error or rules of thumb, in order to support their design decisions. Instead of searching for new information, children used their prior knowledge and took quick decisions (see Table 5.21) similar to ones that had turned out to be successful for similar cases in the past. This result is consistent with other research studies that have identified a number of simplifying strategies in making decisions. These simplifying strategies are called “heuristics” and, based on them, adults and children may use simple rules for decision-making when faced with complex decisions (Gigerenzer, 2001; Tversky, 1972). Children in the study mainly used what Stanovich and West (2000) named “System 1 cognitive functioning”, which is a heuristic approach that refers to our intuitive system, which is typically fast, automatic, effortless, implicit, and emotional. People make most decisions in life using System 1 thinking (Stanovich and West, 2000).

- During observations participant observers noted (see Table 5.21) that older children (aged 14-15) took quicker decisions and used less sources of information before taking a decision than younger children (aged 12-13). Similar results were suggested by Davidson (1991a) who concluded that older children (aged 10) are searching less information as compared with younger children (aged 8).

Based on the research outcomes of the pilot and the main studies and from the literature reviewed, it emerged that children follow various decision-making strategies in order to take a decision. Some of them include heuristic approaches (Gigerenzer, 2001; Tversky, 1972) and others were more systematic decision-making strategies attempting to follow a sequence of rational decision-making steps (Bazerman, 2005; Hammond, Keeney and Raiffa, 1999).
• Children’s Age

There is limited literature relevant to the effect of age on children’s decision-making capabilities. Some studies suggested that older children usually employ more systematic and more efficient strategies as compared with younger children (Davidson, 1991a, 1991b; Ford, Schmitt, Schectman, Hults, and Doherty, 1989; Klayman, 1985). From the results of the pilot studies children’s ages also seemed to have an effect on children’s decision-making strategies. From the outcomes it can be seen that children at the age of 14-15 were more able to describe how one decision might affect their forthcoming decisions when compared with children at the age of 12-13. At the same time, the pilot study found that older children (aged 14-15) used different sources of information when compared to younger children (aged 12-13). From those outcomes it is emerging that age is a significant factor that affects children’s capabilities and difficulties in reaching a decision (emerged category 1, from Table 4.36).

The main study results also reflected the effect of age on children’s decision-making approaches. Age seemed to have an influence on children’s decision-making strategies in many ways. Based on the results of the main study some of the differences identified are the following:

• Older children (aged 14-15) used different sources of information as compared to younger children (aged 12-13). Younger children usually used teachers as a main source of information or existing projects, whereas older children relied more on their peers, the internet and trial and error techniques (Tables 5.3, 5.8, 5.13 and 5.18).
• Older children (aged 14-15) searched for less sources of information as compared to younger children (aged 12-13).
• From Tables 5.13 and 5.19 it can be seen that older (aged 14-15) and younger (aged 12-13) children described different types of evaluation criteria, with younger children relying more on the attractiveness and older children referring more often to criteria such as functionality, time limitations and cost.
• From Table 5.15 it can be seen that older (aged 14-15) children expressed the belief that a design decision already taken will affect their next design decisions more often (19 out of 37) as compared to younger children (aged 12-13) (8 out of 37).

The effect of age on children’s thinking ability has also been identified in other research studies (e.g. Davidson, 1991a, 1991b; Klayman, 1985). Based on those outcomes, age seems to be a
factor with a significant role in children’s decision-making strategies in design and technology education.

- **Transfer of Skills**

Transfer of thinking skills from school activities to other areas of life is considered to be an important issue in the literature reviewed, but in practice seems to be complex. The concept of transfer is under considerable debate for many researchers (Detterman, 1993; Dyson, 1999; Hammer et al., 2005; Mestre, 2005). The related literature on transfer of knowledge and skills (Hennessy and McCormick 1994; McCormick 1999; Levinson et al. 1997) suggests that transfer is not easy.

The results of this study also identified the difficulty in transferring skills from one domain/environment to another. The pilot study identified the difficulties of transferring skills from the school environment to other everyday activities (emerged category 12, from Table 4.36). There was some evidence from the pilot studies about the transfer of children’s skills from one design task to other design tasks (emerged category 13, from Table 4.36) within the same domain (for example product design). Both teachers and children seemed to agree that learning is mainly domain specific and very rarely can be observed to transfer to other activities.

In the main study, children were asked during their pre-observational interviews if they believed that they transferred decision-making skills from the subject of design and technology to other areas of life such as personal purchasing. From the 15 students interviewed only 3 of them expressed the belief that they could describe a case where they transferred skills from the classroom to other activities (Table 5.7). For example a child said: “When you go to buy a pair of shoes, most of the times you’re choosing among two or three pairs and you have to take a decision. It is similar to what we are doing in design and technology when we have to choose among alternative ideas”. Most of the students (12 out of 15) believed that they cannot transfer skills from the school environment to their everyday activities, for example a child said during the interview: “I don’t believe that what we are learning in schools can be used in other areas of life”.

From the results of the interviews (Tables 5.4 and 5.9), pre-tests and post-tests (Tables 5.26 and 5.28), children were more able to describe detailed evaluation criteria for their personal purchasing decisions (e.g. buying a mobile phone) as compared to criteria for their design projects or any other fields. This outcome is showing that the transfer of skills from the school
environment to real-life contexts and vice-versa is not very clear and needs more careful consideration.

During the design of their projects children explained in their log-books how they reached a specific decision and if the decision they made would affect the forthcoming decisions of their project. This type of question aimed to explore if children would be able to transfer the consequences of a certain decision to a decision that follows. From the results (Table 5.14) 74 out of 110 children replied that a decision already taken will not affect their next decisions and only 36 out of 110 believed that the decision already taken would affect their next decisions.

The difficulty of the transfer of skills from teaching in schools to other domains has also been identified from other research studies (Hennessy and McCormick, 1994; McCormick, 1999) which suggest that there is little evidence to support the existence of transfer, although it is often anticipated that children will transfer the skills gained though designing to their everyday decisions (Carraher and Schliemann, 2002; Hennessy and McCormick, 1994; Welch, 2007;). Based on that evidence the skills learned in design and technology are mainly domain specific and the links between them and other activities are not clear.

- **Influence from Children’s Peers**

  From literature reviewed (Bendelow and Mayall, 2000 Schaffer, 1996) peers seem to have an effect on children’s learning and as a result their decision-making strategies. Schaffer (1996) suggests that peer to peer mentoring is likely to improve educational activities. For most children friendships and companionships are critical to their enjoyment, together with work in which they could participate actively.

  Based on the results of the pilot studies, the observations and children’s interviews it is emerging that peers seem to affect children’s decision-making strategies. Children said during their interviews that they discuss their ideas with peers and sometimes adopt similar ideas with them. Observations also suggested a similar conclusion; children were making similar decisions to those of their peers within their group (emerged category 14, from Table 4.36). Based on that evidence, peers seem to have effects on children’s decision-making strategies.

  The findings from the main study also identified similar outcomes from various sources of data collected. From Table 5.3 it can be seen that 12 out of the 15 children when asked during their
pre-observational interview named peers as an important source of information for their decisions. Older children (aged 13-14 and 14-15) seemed to be affected more than younger children (aged 12-13) from their peers. A possible explanation for that is because older children had spent more time in the same class when compared to the younger children. Children joining the lower secondary school came from various primary schools. When placed in a new class in the secondary school, they normally stay together for the next 3 years, and as a result children at the age of 14-15 have been in the same class for more than 2 years as compared to children at the age of 12-13 who had been together in the same class for only a few months when the research took place. The effects of peers on children’s decision-making strategies were also identified from children log-books (Table 5.14) where 50 out of 110 children mentioned peers as a source of information. Peers’ interactions were also found during observations where children were free to talk about their design decisions (Table 5.18). The effect of peers on children’s behaviour has also been identified from previous studies (Slavin, 2003; Wertsch, 1985).

- **Children’s Difficulties**

Difficulties that prevent children from reaching an optimum decision were identified from literature reviewed (Davidson, 1991a and 1991b). Bazerman (2005) suggested that adults and children during decision-making often lack information on the definition of their problem or the relevant criteria. There are also time and cost constraints that limit the decision strategies. A number of difficulties that children faced during their decision-making strategies were identified from the pilot studies. Many children do not search for any kind of relevant information in order to develop their theoretical background to support their design decisions. They also face difficulties in setting or handling criteria for evaluating and on which to base their decisions. Another difficulty that emerged from the pilot studies is the lack of motivation that children appeared to have for the designing part of their projects, and as a result towards their design decisions (emerged category 9, from Table 4.36). Therefore children’s difficulties will affect their decision-making processes.

The difficulties that are involved in children’s decision-making strategies that were identified from the main study are summarised as follows:

- Some children were unable to search for relevant information (Table 5.22) in order to reach a decision. They mainly relied on the information given by teachers and rarely searched for information outside of the classroom. A difficulty in distinguishing relevant from irrelevant information was also observed, which is an outcome that was also identified by Davidson (1991a and 1991b).
Another problem was that children had difficulties in specifying criteria other than attractiveness (Tables 5.9 and 5.22) and especially younger children (aged 12-13). Difficulties in setting and evaluating appropriate criteria in design decision-making were also identified by Mettas and Constantinou (2008) with slightly older children (aged 18-19).

In the case of decision-making tasks with multiple and conflicting assessment criteria children were unable to handle all criteria and reached a decision that satisfied most of them. The difficulty in handling assessment criteria was also identified by Bazerman (2005), Mettas and Constantinou (2008) and Mettas, Thorsteinsson and Norman (2007).

Children mentioned lack of confidence in taking a decision (Table 5.11). This outcome could also have been due to their lack of experience as Barlex and Miles-Pearson (2008) also found.

Children had difficulty in relating a design decision taken with the decisions that will follow (Table 5.15). This outcome could be partly due to the difficulty of transferring existing knowledge and skills to other situations (Gick and Holyoak, 1980; McCormick, 1999; Welch, 2007).

Another difficulty was that children seemed to have a lack of motivation in decision-making in the school environment (Table 5.22). Lack of motivation was also found by Klaczynski et al., (2001) who argued that it takes effort to consider options carefully and so it may not be worth the effort if one does not care about the decision. McCormick (2004) argued that in design and technology the design decisions should matter and mean something to the children, in a way that will enhance children’s motivation about the design decision tasks.

Based on the literature reviewed and the results that emerged from the pilot and the main studies as discussed above, a number of difficulties have been identified as being involved in children decision-making techniques within design and technology education.

**Factors that Affect Children’s Decision-Making**

Based on the factors studied above, as obtained both from the pilot and the main studies and from the literature reviewed, Figure 7.3 presents graphically the factors influencing children’s decision-making processes. Children’s decision-making is at the centre of this representation and is surrounded from the factors that were identified in the discussion above.
7.2.4 The Role of the Curriculum

As discussed in the literature reviewed (Barlex and Rutland, 2003; Jones, 2003; Prideaux, 2003) the requirements of curriculum materials affect the content and the types of the decision-making opportunities given to children. Barlex and Rutland (2003) pointed out that the nature of the design decisions that the pupils are expected to make as required from the curriculum is an important factor in determining their progression. Jones (2003) argued that design and technology curricula need to emphasise a child-centred approach that is central to human experience, values, culture, and social forces.

During the pilot studies the requirements of the design and technology curriculum materials of three countries (England, Cyprus and Iceland) were explored. From the outcomes it could be seen that curricula included many decision-making opportunities. For example the English national strategy (2004) requested that “Children take decisions upon materials, time and production”. The effect of curriculum materials on their teaching was also identified by teachers who were interviewed as part of the pilot study. Observations similarly identified the effect of the curriculum on the teaching and learning and therefore on the application of decision-making skills within the school environment. From the results of the study, teachers reported that despite the curriculum requirements there are various opportunities for teachers to manage and organise decision-making activities.

As concluded from the pilot studies the role of the curriculum is very important in children’s decision-making strategies (pilot study, emerged categories 3 and 15, Table 4.36). The
important role of the curriculum was also identified from the literature reviewed. Prideaux (2003) pointed out that curriculum material includes all the planned learning experiences of a school. In addition, Davis and Krajcik (2005) pointed out that the curriculum designers must ensure that curriculum materials include multiple opportunities for students to explain their ideas and develop their skills. Teachers will determine the curriculum requirements in terms of the assessment criteria that the pupils must meet; in that sense ‘assessment drives the curriculum’. Therefore the requirements of curriculum materials play a central role in teaching and learning and hence in the development of decision-making opportunities within design and technology education.

Based on the outcomes of the study and the literature reviewed, it can be suggested that the curriculum determines what teachers teach, and as a result what children learn. The curriculum also specifies the knowledge, skills and values that children need to acquire in a certain age level. Therefore, the requirements of the curriculum have a central position in the development of the model that explores the factors that affect children decision-making in design and technology education.

7.3 The Theoretical Perspective of the Study

Taking into account the literature reviewed and the results of the pilot and the main studies, a model was designed that addresses possible factors that are involved in children’s decision-making processes in design and technology education. The model is based on the findings that emerged from the research studies conducted. The findings were also related with the relevant literature reviewed where this was feasible in order to strengthen the model. In the centre of the model is the decision-making as an activity which is affected from outside-class factors like knowledge, skills and values. Other factors such as the requirements of the curriculum are in between teachers’ and children’s capabilities and ideas. The reason that the curriculum is in between them is because its requirements are affecting what teachers teach and as a result what children learn. A graphical form of this model is presented in Figure 7.4.
Figure 7.4 - Model for factors affecting children’s decision-making in design and technology

From the model presented in Figure 7.4 it can be seen that the curriculum plays a central role in the teaching of design and technology and hence on decision-making opportunities given through the teaching and learning of design and technology. The content and the requirements of the curriculum will affect the nature of the design tasks that teachers required from children. Therefore, the way teachers implement the curriculum, their own ideas about teaching and learning and the teaching resources that they are using in their classes will have an effect on the development of children’s decision-making strategies. The nature of tasks that teachers give to children should be based on the curriculum, but at the same time should be meaningful to children and be related to the real world in order to achieve higher levels of children’s interest. The importance of the curriculum and the nature of activities that teachers offer to children has also been identified by other researchers (Barlex and Rutland, 2003; Jones, 2003; Prideaux, 2003).

In addition to the curriculum and the teacher’s role, children’s ages have a significant role. It seems that there are differences in the approaches and the strategies that children with different ages (in the range 12-15) follow in their decision-making.
From the findings it can be suggested that children’s decisions were also affected from their peers (Bendelow and Mayall, 2003; Schaffer, 1996). Sometimes children take similar or identical design decisions with their peers. Children’s are not ‘tabula rasa’ and bring ideas from their everyday activities to their class and vice-versa. Therefore their ability to transfer skills from one area to another, although it is not very clear from the research, might affect their design decisions. Possible difficulties they are facing as a result of being ‘fledgling designers’ (Trebell, 2007) will have an influence on their ability to make decisions. The term ‘fledgling designers’ was developed to broaden the five levels of expertise, which consist of ‘novice’, ‘beginner’, ‘competent’, ‘proficient’ and ‘expert’ to add a category particularly for pupils in schools, who will be employed in designing without prior experience and proficiency in the field (Trebell, 2007).

Difficulties that were identified from the pilot studies and added to the theoretical model are children’s lack of motivation, difficulty in handling evaluation criteria and the difficulty in searching for relevant sources of information to support their decisions. The strategies that students follow in order to take their design decisions are also affecting their choices. Some strategies that were identified from the research explain how children approach decision-making tasks; they usually rely on their existing knowledge in order to reach a decision, usually they follow some heuristics approaches, trial and error, or rule of thumb, and less often they follow a systematic approach that includes searching for all possible options, evaluating those options and reaching a decision based on specified criteria. Similar difficulties were also identified by other researchers that have investigated decision-making as a human activity (Barlex and Miles-Pearson, 2008; Davidson, 1991a; McCormick, 2004; McCormick, 1999; Mettas and Norman, 2011; Mettas and Constantinou, 2008; Welch, 2007).

Another group of factors that are part of the model are knowledge, skills and values (Coles and Norman, 2005; Hicks et al, 1982; Norman, 1998; Pedgley, 1999; Trimingham, 2008). Every task given to children will include knowledge, skills and values to some extent. Teachers need to give children tasks that enhance their capabilities to improve their knowledge, skills and values and at the same time need to consider that task will be suitable for the children’s age level.

The model, as presented above, explores the factors that are involved in children decision-making in design and technology education. The factors in the model also have relationships and interactions between them. Those interactions might affect children’s design decision-

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1 Tabula rasa: a mind not yet affected by experiences, impressions, etc.
making processes and a possible change in one factor might have an effect on the others. Therefore policy makers and curriculum developers need to treat decision-making as a model and not consider factors independently. The relationships between the different factors in the model need to be explored through further research in order to examine their contribution to children’s decision-making strategies.

7.4 Discussion of Results Related to Research Questions

The data collected and analysed provides information about the research questions of the study. In this part of the discussion, the results from various data sources that are relevant to each research question are related together to provide deeper knowledge and insights. The following sections discuss the main findings of the study for each research question as they emerged from literature reviewed, the pilot and main studies.

7.4.1 RQ1 - The Types of Decisions that Teachers Expect Children to be Engaged when Designing and Making

Teachers expect children to be engaged in various types of design decisions when working with design and technology activities. During the interviews with teachers, they identified some of the decisions that they expected children to take. Some of these include, how the item will look like, how they will make it and what materials they will use (Table 4.2). During the main study, children identified the types of decisions that they were normally engaged in during design and technology projects. Children reported choosing the materials for their designs, the shape/aesthetics of the construction, and possible functional aspects (Tables 5.6 and 5.10). For example a child said during the interview: “our teacher explained to us the materials that were available and we made our decisions for the most appropriate material in each case”. Similar types of decisions were identified from Middleton (2005) who suggested that children are usually dealing with decisions about construction materials and processes to use. The types of decisions that are usually required in design and technology education were previously explored by Barlex and Rutland (2003), Barlex (2005) and Trebell (2011).

Barlex (2005) described five areas in which children usually take their design decisions in design and technology education; (a) conceptual (b) marketing (c) technical (d) aesthetic and (e) constructional. From the research outcomes of the study it can be seen that a number of conceptual decisions (Tables 5.10, 4.21) were made by the children mainly about the purpose
of their product. Technical decisions were more evident, from the results of interviews (Table 5.10), observations (Tables 5.13) and log-books (Table 5.19), according to children functionality of their products was seen as very important. From the results aesthetic decisions were the most frequent decisions that children took within this research (Tables 5.13, 5.19, 5.10). Constructional decisions were also identified during interviews (Table 5.9) observations (Table 5.19) and in children log-books (Table 5.13). Children decided how they will connect the different parts of their designs. From the results of the study there were no significant marketing decisions made by children as Barlex (2005) and Barlex and Rutland (2003) proposed. This might have happened because the children were taking their design decisions spontaneously and did not consider marketing issues during the design phase of their products. The emphasis on marketing issues in the Cypriot curriculum is also limited and children do not usually take decisions in that area. They normally design products for themselves as part of their design and technology activities.

Trebell (2011) added two new categories in Barlex (2005) types of decisions; the first deals with materials and the second deals with safety. From the results of the study children’s decisions about materials were observed extensively during the research study, during the interviews (Tables 5.6 and 5.10), from the log-books (Table 5.13) and during the observations (Table 5.19). Decisions about safety issues were not very evident from the research results, although some children considered safety factors in their designs. Additionally to Barlex’s (2005) and Trebell’s (2011) types of design decisions, the results identified decisions taken by children with regards to the cost of their designs and decisions relevant to the management of their available time to design and make their product (Tables 5.5, 5.9, 5.13 and 5.19).

From the results of the study (Tables 5.13, 5.19, 5.10) it can be seen that most design decisions taken concerned aesthetics and then construction and technical issues. Similar results were identified by Welch and Barlex (2009) in their study with elementary school pupils; where they found that the majority of the design decisions made by the pupils were concerned with aesthetics and construction, although there was a brief discussion concerning the technical issues.

The research studies identified some other types of decisions that teachers expected children to take. The decisions were related to the generation of alternative ideas and then choosing the best possible idea among them based on some criteria they set to evaluate their options. When a number of alternative ideas had been put forward, the children had to make decisions about
their appropriateness in relation to the design brief or the task given to them. From Table 5.12, it can be seen that children usually generated 2 or 3 alternative ideas for their designs in their log-books. Older children (aged 14-15) generated fewer ideas as compared to younger children (aged 12-13). The generation of alternative ideas turned out to be difficult for children. The difficulty in generating creative ideas has also been reported by Nicholl and McLellan (2007a and 2007b) as well. In their study, children faced difficulties to design creative ideas and they explained that this was partly the result of fixation. They defined fixation as the “difficulty in generating novel ideas due to imagination being ‘structured’ by pre-existing knowledge” (p.71).

During their interviews children said that they usually decided on the idea they will make first and then they would draw some other alternative ideas in order to fulfill teachers’ assessment requirements (Table 5.11). For example a child said during the pre-observational interview: “I know from the beginning of the project the one that I shall make (idea) at the end, but because teachers asked for alternative ideas, I am drawing 3-4 additional ideas”. The difficulty with the assessment requirements in design and technology and its negative effects on children’s creativity has also been observed by many other researchers (Kimbell, et al. 1991; McCormick, 2004; McCormick, 1999)

Additional information on the types of decisions that teachers expect children to be engaged was also identified from the observation results. From Table 5.20 it can be seen that observers noted that teachers gave children projects that linked knowledge to meaningful, real-world contexts. The importance of meaningful tasks was argued by McCormick (2004) as well. He argued that in design and technology education the learning has to be meaningful to children. If for example the activity is to make a design decision, it should be a decision that matters and means something to the children, in a way that will enhance children’s motivation about the design decision tasks. In addition, Davis and Krajcik (2005) argued that teachers are expected to teach meaningful content that helps children to meet learning goals in the context of authentic activities and ensure children’s successful learning. Fox-Turnbull (2006) also point out that an important issue of activities that children undertake is that authentic learning engages children and encourages learning.

There are limitations for teachers on the types of design projects or design decisions that they are able to give to children. Teachers are following the guidelines of the curriculum in order to decide the content of the activities that will require by their children. The model presented earlier in Figure 7.4 explored the various factors that are involved in children decision-making. Those
factors are affecting the types of design decisions that teachers can give to their pupils. For example, children’s age or children capabilities will affect the type of decisions that a teacher could require from them. Teachers’ difficulties and problems of curricular choice and coverage were also identified from Anning et al. (1996) and from classroom and school administration expectations from Banks et al. (1999). All those issues might have an effect and limitations on the types of decisions that teachers are able to offer to children.

Based on the results of the research, it can be argued that teachers are expecting children to be engaged in various decision-making activities. During their interviews (teachers’) they identified various types of decisions that they expected children to take such as, aesthetics, technical and constructional. From the findings of the study teachers expressed the belief that their expectations will formulate the types of decisions that will be set to children. The literature reviewed also suggests that teacher views of teaching and learning, as well as their expectations from children have a direct impact on the way they teach (Pajares 1992). Davis and Krajcik (2005) suggested that curriculum is affected by characteristics of the teachers, such as their knowledge, beliefs, and dispositions toward reflection and improving their own practice (Collopy, 2003; Schneider and Krajcik, 2002).

Teachers organise their teaching activities in a way that leaves children various decisions to be taken such as construction materials, shape of the construction or the mechanism that will be used. In effect, teachers are providing the children with constrained design experiences, not open-ended design activities. For example a teacher said during the interview: “there are some design decisions taken in advance by the teacher, for example the type of the project but there are still many decision to be taken by children such as construction materials, aesthetics, or technical issues”. Rutland and Barlex (2008) concluded in their study that the teacher was the key factor in fostering creativity and decision-making by influencing pupils. According to Rutland and Barlex (2008), an important factor of successful teaching is the ability of the teacher to provide a secure, rewarding, supportive, well-resourced and safe classroom environment where pupils were encouraged to take risks and work co-operatively.

7.4.2 RQ1a - Decision-Making Opportunities in Design and Technology Curricula

As discussed earlier in this Chapter in Section 7.2.4, the design of the curriculum has a significant influence on what teachers will teach and how they will derive decision-making tasks for children that are based on the curriculum (Prideaux, 2003). From the review of the design
and technology curricula in England, Cyprus and Iceland it can be seen that their guidelines included various decision-making opportunities. This outcome was supported by the review of curriculum materials to the three countries (Tables 4.12-4.14). For example the Cypriot National Curriculum (2001) states: “Pupils choose the appropriate components for the input, process, and output of an electronic system”.

The decision-making opportunities that were required from the curriculum materials were also acknowledged from teachers (Table 4.4). During their interviews, teachers from the three countries argued that although curriculum materials included many opportunities for decision-making activities, in practice some of them are difficult to apply. For example a teacher said during the interview: “The curriculum does allow opportunities for design decisions but these may be limited by resources available or what is practical in a lesson”.

From the analysis of the curricula it can be observed that the English and Icelandic curricula are framed more in process terms when compared to the Cypriot curriculum. In the English and Icelandic curricula designing and making provide the cornerstones of the design and technology curricula, from which knowledge and skills are supported. For example, the English National Curriculum (English National Strategy, 2004) required that “pupils seek out information to help their design decisions”, but does not specify in which technological area to take that design decision.

The approach of the Cypriot curriculum is more content oriented (as compared with the English and Icelandic) and the subject is usually conceived in terms of major sub-divisions, such as communications, mechanisms, electronics, structures, and energy. Design decisions have to be taken within a specific technological aspect within such sub-divisions. For example the Cypriot curriculum required that pupils: “decide the appropriate appearance, mechanism and decoration”. Hence, the Cypriot curriculum specifies the technological area within which the decision should be taken (mechanisms).

The curriculum guidelines of England and Cyprus both required decision-making opportunities to be provided in technological contexts. For example: “Make and justify decisions regarding the choice of materials and manufacturing processes and use them to draw up a manufacturing specification” (English NC, aged 13-14), or “Choose the appropriate components for the input, process, and output of an electronic system” (Cypriot NC, aged 14-15). The Icelandic curriculum specified less design decision requirements for children and gave more emphasis on innovation.
in products that children were required to design and make. For example: “Take sustainability into account in their design decisions” (Icelandic NC, aged 14-15).

Curricula in England and Cyprus required children to search for relevant information in order to support their design decisions and to specify detailed evaluation criteria before reaching a decision (Tables 4.12 - 4.13). For example: “Select information sources, gathering and sorting data that will help with decisions about, the design” (English NC, aged 13-14) or “Children should search information and decide upon the appropriate shape, materials, size, strength, use, and decoration of their project” (Cypriot NC, aged 12-13). Children were also required by the curriculum specification to justify of any design decision taken for their projects. The importance of the investigation and evaluation of information in education was also identified from Venville, et al. (2004), Roth, (1998) and McCormick (2004).

Despite the appearance of decision-making opportunities in the Cypriot curriculum, from the review of the books that are used in for supporting Cypriot teachers it can be seen that books do not include significant decision-making opportunities. The books that are currently in use in the Cypriot schools for design and technology education are mainly content based. In terms of decision-making the books are useful to the children only in searching for the information that they might need before taking a certain decision (Table 4.7). This outcome was also supported from teachers’ interviews during the pilot study; for example a teacher said: “many books that are in use for design and technology teaching are extremely focused on delivering information”.

From the analysis of the results and from the literature reviewed, it can be suggested that the curriculum guidelines have influence on the nature of the design tasks given to children’s (Davis and Krajcik, 2005; Prideaux, 2003). The design activities that teachers set to their pupils as part of this research were affected by the requirements of the curriculum. This outcome emerged from teachers’ interviews where teachers from England, Cyprus and Iceland reported that they follow the guidelines of the curriculum materials and the design tasks that they set to children are mainly based on the curriculum materials.

In the case of Cyprus this outcome was also found from the observations undertaken as part of this study (Table 5.20). The activities that the teachers were observed to set to children were mainly derived from the curriculum documents. From the observations, 8 out of 24 times researchers suggested that the activities derived from the curriculum were somewhat apparent and 16 out of 24 reported that the activities being derived from the curriculum was definitely
apparent (Table 5.20). This outcome is suggesting that teachers in Cyprus are following 'centralised guidance' based on the national curriculum and as a result teacher autonomy to set their own educational activities is not very strong.

On the other hand from Table 5.20 it can be seen that although the project was derived from the curriculum, at the same time it was linked to a meaningful, real world context according to the observers (20 out of 24 noted that this was somewhat or definitely apparent). These findings confirm that the Cypriot curriculum includes requirements that are related to the real world context. These results are consistent with other research studies (Jones, 2003; McCormick, 1999; Prideaux, 2003) in the area of curriculum development that have suggested that the curriculum needs to include real world activities that are meaningful to children.

7.4.3 RQ1b - Decision-Making Opportunities Given by Teachers to Children

Teachers’ role in giving opportunities to children with carefully designed tasks that included decision-making opportunities was previously discussed in Section 7.2.2 as part of the design of the decision-making model (Figure 7.4). The importance of giving decision-making opportunities to children in design and technology was identified from the literature reviewed (Barlex and Rutland, 2008; Davies, 2004; McCormick, 2004). Davies (2004) suggested that an important characteristic of a design and technology teacher is to give opportunities to children to make their own design decisions. The results of the study also suggested that teachers offered various decision-making opportunities to children within design and technology education.

Teachers reported during their interviews that they offered various decision-making opportunities while children were engaged with design and technology activities. Based on teachers’ interviews, they considered themselves to act as facilitators of what children are investigating and promote the autonomous learning of decision-making by children. According to teachers, the opportunities given and the decision-making tasks became more complex as children grew up (Table 4.3). For example, a teacher said during the interview: “I have more requirements from older students as they have learned working with design and technology processes, but with younger children most of the times the project is mainly driven by the teacher”.

The findings of the current study are consistent with those of Black (2008) who argued about the importance of the development of children’s autonomy in design and technology education.
Black (2008) points out that design and technology should be taught in a way that pupils’ autonomy is developed and pupils are required to make their own decisions about their designs.

The decision-making opportunities that teachers offer to children are important since they are giving the chance to children to develop and implement their decision-making skills. Based on the discussion earlier as part of the design of a model that describes the factors that are affecting children decision-making in design and technology (Figure 7.4), teachers have an important role on children learning. Prior studies have also noted the important role of teachers on children’s learning. Rutland and Barlex (2008) in their study with 11-14 children in UK argued that teachers have an influence on pupils learning and the development of their skills.

During the classroom observations, researchers identified decision-making opportunities which were given to children while designing their projects. From the results of Table 5.16 it can be seen that teachers used various activities such as design projects and experimentation that offered decision-making opportunities. The decision-making opportunities that design and technology education offers to children were also identified from the literature reviewed. Rutland and Barlex (2006) also found that there was a range of decision-making opportunities given to children while observing food technology teachers trainees teaching design and technology.

From the observations the activities that were related more with decision-making opportunities were hands-on activities, class discussion and seated work. Children’s hands-on activities and seated work were mainly related with the exploration of various materials or equipment. This exploration served as a means of developing their theoretical background in relation to the decision that it was intended to make. This finding supports previous research of Rutland and Barlex (2006) who observed children while designing and they argued that when pupils were following more open investigations, more design decisions were taken by them. According to Vidal (1994) learning by discovery is supported both from Piaget, Vygotsky and Bruner and provides opportunities for learners to explore and experiment, thereby encouraging new understandings.

Class discussions were also related with more engagement of children in decision-making activities. During that stage discussions between teachers and children and between children and children were taking place. The discussions were mainly focused on the design decisions that children needed to take as part of their project. These open activities (without formal teaching) gave children the autonomy to work independently and to take their own design
decisions. The effectiveness of this teaching activity was also suggested by Trebell (2008) and Rutland and Barlex, (2008). Trebell (2008) suggested that classroom activities that give children greater independence empower pupils in their learning.

Children’s discussions between themselves and with their teacher seemed to engage children more effectively in decision-making. Based on observers’ notes during that stage children were talking and explaining their ideas to their teacher and to their peers and justified their design decisions. Similar results were identified from literature reviewed in previous research. Welch and Barlex (2009) investigated children’s behaviour while designing through the use of exploratory talk (talking aloud) and they concluded that pupils were more able to make better design decisions through that activity. In addition to that Hamilton (2007) argues that sociocultural perspectives on learning place an important emphasis on the use of language in the construction of meaning. Hamilton (2007) supported that “design and technology, with its emphasis on problem solving and goal oriented activity, has real potential for harnessing the creative energy and critical thinking skills of children’s through collaborative and contextualized activity.” (p.34).

During observations the researchers noted whether the lesson observed included decision-making opportunities and the type of those opportunities. From the results as presented in Table 5.20 it can be concluded that during the design project 18 out of 24 observations reported that the lesson definitely included decision-making opportunities. A further 6 out of 24 observations reported that decision-making opportunities were somewhat apparent during the project. From the results none of the observers noted that there were no decision-making opportunities for children (Table 5.20). The types of decisions taken during that phase were discussed in Section 7.4.1 and included aesthetic, conceptual, technical, constructional, time management and appropriate materials issues.

From the observations, it can be seen that teachers’ ideas and strategies have an important role in determining children’s decision. In Table 5.20 observers noted that design decisions were somewhat driven by teachers (14 out of 24). The observers’ notes indicated that most decisions were taken by children after a discussion with their teacher. This is not to say that teachers were suggesting a specific choice, they were rather challenging children with various options available. Observers also noted that in some cases decisions were driven mainly by teachers (4 out of 24) or and in some other cases were driven mainly by children (6 out of 24). The results are suggesting that during decision-making various interactions between teachers and children
exist. Observers argued that most decisions are pursued as a result of the interaction between teacher and children and children to children and the outcome (design decision) is the result of such collaborations.

The idea that child’s ideas and decisions are affected from teachers’ beliefs and that the learning process is an outcome of this interaction has also been identified from previous research. Hamilton (2007) argues that teachers act as facilitators and as resources within the dynamics of the interactional process. As an active and responsive participant, the teacher can become an important catalyst for effective learning (Hamilton, 2007). Neisser (1976) also argued that children tend to direct attention to what teachers say. From this point of view children’s design decisions are also affected by teachers’ ideas (and maybe from the assessment criteria) and usually the outcome is the combination of their efforts. The influence of teachers’ ideas on children’s design and technology projects was also identified by McCormick (2004).

From the results of the study and the literature reviewed, it can be suggested that there are various decision-making opportunities that teachers offer to children during their engagement with design and technology projects. The pedagogical strategies and the learning activities that teachers follow are very important for children’s learning. Prior studies have noted the importance of teaching strategies. For example, Trebell (2009) argued that the pedagogic strategies adopted by the teacher either facilitates designerly decision-making or prevents it.

**7.4.4 RQ2 - Children’s Decision-Making Strategies in Design and Technology**

Children follow various decision-making strategies in order to take their design decisions. A number of studies (Howse et.al., 2003; Klayman, 1985) have found that some strategies involved an extensive search of the alternatives and their dimensions (high-processing) while other strategies involved making a decision without looking at all the available information (reduced-processing).

The results of the research study identified a number of strategies that children employed in order to take their design decisions in design and technology education. The strategies as emerged from the study were discussed extensively in Section 7.2.3 since children’s strategies were considered to be part of the decision-making model (Figure 7.4).
The strategies that emerged from the research study and the theoretical model are summarized below:

- Whenever children needed information in order to take their design decisions they tended to use teachers as a source of information and sometimes expected teachers to suggest a decision for them.
- Children were specifying some criteria that the decision needed to fulfil and took their decision based on those criteria. Criteria were usually related to their values, interests, or their available time.
- Usually children followed simplified processes such as trial and error and rules of thumb and using their existing knowledge in order to reach a design decision.
- Older children (aged 14-15) took quicker decisions and use less sources of information before taking a decision as compared to younger children (aged 12-13).

These strategies identified from the research study provide useful information for teachers to consider when designing decision-making tasks for their pupils in design and technology education. From the results, it seems that children do not necessarily follow a systematic approach with ‘logical steps’ before taking a decision and they usually rely on heuristics approaches using their existing knowledge as built from previous work with design projects to take a decision. McNair and Clarke (2007) argued that children could use their previous work to highlight their strengths and weaknesses and pinpoint skills that have been established and those that need to be developed. However, such a strategy depended on teachers themselves taking a developmental approach to such skills as well as managing the satisfactory completion of the elements of the design-and-make work.

The strategies of children might be affected from lack of motivation (McCormick, 2004) or could be a result of time limitations or the difficulty of identifying all possible alternative options and their consequences. For children (and for adults), not every action deserves extensive thought and analysis before taking action (Clemen, 1991). A possible explanation for this outcome could be that teaching activities that teachers follow are not always meaningful to children.

7.4.5 RQ2a - Children’s Sources of Information for their Decision-Making

A research sub-question was investigating the sources of information that pupils (aged 12-15) prefer to use when making a design decision. Clemen (1991) argued that information is required
in order to improve knowledge and therefore to make good decisions. There are various sources of information that children can reach in order to gain the required knowledge that will guide their decisions. Children also need to evaluate the information and distinguish relevant from irrelevant information. Sadler et al. (2004) suggested that information evaluation needs to be a strong component of scientific and technological issues curricula and instruction.

The pilot and the main studies identified various sources of information that children preferred to use in decision-making situations. The analysis of data such as interviews, log-books and observations provided details about the types of sources of information that children used in design and technology education and the frequency that they used them. Table 7.1 is presenting and comparing the main sources of information that identified from the data analysed.

From Table 7.1 it can be seen that teachers served as the most frequent source of information for children during decision-making in design and technology projects. A possible explanation is that for children, the teacher is the easiest source of information to access within the class. Another possible reason is the fact that children tend to consider teachers as an authentic and very reliable source of information. For example ‘child 15’ said during the pre-observational interview that: “I will ask my teacher since he knows more about those issues”.

The findings of the current study are consistent with those of McCormick (2004) who found that teachers were considered to be an important source of information for children’s design work. Neisser (1976) also argued that children tend to direct attention to what teachers say and as a result are source of inspiration for them. The important role of teachers in the learning process was acknowledged in Rutland and Barlex’s (2008) study where most pupils considered the role of the teacher as important in creating a supportive atmosphere, where pupils developed knowledge, understanding and skills in materials and techniques and as a result they made informed choices. Venville, et al. (2004) also argues that the teacher was a respected source of information and was well used by children at one time or another in the design project.
A. Mettas PhD 2011

Chapter 7: Discussions

<table>
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<tr>
<th>Data Collection Method</th>
<th>Source of Information</th>
<th>Frequency Used</th>
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<tr>
<td></td>
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<tr>
<td>Pre-observational Interview (N=15) (5 in each age group)</td>
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<td>Peers</td>
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<td>Additional Book</td>
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<tr>
<td>Post-observational Interview (N=15) (5 in each age group)</td>
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<td>Existing projects</td>
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<td>Personal Interests</td>
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<td>Trials-Experiential investigations</td>
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<td>Additional Book</td>
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<tr>
<td>Children Log-books (N=110) (37 in each age group)</td>
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Table 7.1 - Children’s sources of information identified from the main research

From the analysis of results of Table 7.1 peers seem to be the second most important source of information that has an influence on children’s decisions-making activities. Many children referred to peers as sources of information for their decisions. Children consider their peers as a very important source of information that they referred to very often, for example a child said during his pre-observational interview: “of course I will get some ideas from my friends”. Literature reviewed also acknowledged the importance and the existence of peer influence on children learning. Conrad and Donaldson (2004) suggested that child to child interaction is important to Vygotsky’s (1986) theory that children’s learn from viewpoints of others in order to
build a more complex world view. The effect of peers on children’s learning was also identified from Venville, et al. (2004) and Sadler (2004). In addition Barlex and Miles-Pearson (2008) suggested that when pupils have the opportunity to peer mentor their fellow class mates as they learn and the presence of the class teacher might encourage and enable pupils to develop more diverse solutions. This process of networking, using other students as sources of information, reflects Roth (1998) descriptions of learning communities.

From the results it can be seen that children mainly discuss aesthetics decisions with their peers and technical decisions with their teachers. A possible explanation for this might be that children expected that their teacher to be more experienced on technical issues than their peers but in terms of aesthetic decisions they considered their peers’ ideas more closely related to their own ideas.

The internet seemed the third most important source of information for children (after teachers and peers) when taking a design decision. Children explained in their interviews (pre and post observational) and also reported in their log-books that very often they used the internet as a source of information. Children seemed to use the internet as a source of information in almost every type of design decision they require. Simmons (2008) investigated the use of internet with older children (aged 16-18) and he concluded that for many students the use of websites for their design projects was very frequent. The students appeared to access websites on various areas based around the current products on the market. These instances covered six different areas with varying degrees of regularity: “product research; product inspiration; target audience and product comparison; sustainable design issues; images searching; evaluation” (p.42).

The internet was also identified as a source of information for children from other research studies reviewed. Sadler (2004) argued that technological issues often involved ideas from many areas. He goes on and suggests that information of this type is transmitted to decision-makers through a variety of sources including the internet.

The use of internet as a main source of information was not supported from observations, only 13 out of 216 notes made by the observers referred to the use of the internet as a source of information in the class. A possible explanation for this unexpected outcome is that children’s have access to other sources of information (existing projects or teacher or peers) during the teaching of design and technology classes that they cannot access when they are home. Since
the internet is accessible from their home as well, it is possible that they tend to use alternative sources of information while they are in the class environment.

Children arrived with many strongly formed ideas about how the world works (Brown, Collins, and Duguid, 1989). As a result, some children built a body of existing knowledge that they used to take some of their design decisions. Although the existing knowledge was not mentioned by children as a source of information during their interviews its appearance was evident in observations and in children log-books. The use of existing knowledge was identified from children’s look-books in 38 out of 110 cases. They usually used existing knowledge as built from their experience in design and technology to decide about the appropriate materials, they tended to choose materials that they already used before. The use of the existing knowledge was argued by Gilbert (1991) who pointed out that when students face decision-making problems, they very often solve these problems by using empirical knowledge.

Another source of information that was identified by the research was the exploration of existing projects. Through that process children were investigating similar designs and considered possible materials which could be used, aesthetic issues, equipment etc. Based on this evidence existing projects can be considered as a source of information that affected children’s design decisions. Other researchers have also identified the use of existing projects as a source of information (McNair and Clarke, 2007). Venville, et. al. (2004) investigated the sources of information that students employ while working with design activities. Designs that students had used in previous years were used as an important source of knowledge by some children.

From the results of Table 7.1, it can be seen that teachers tended to demonstrate existing projects as good or bad examples of design projects and children were influenced from those projects and as a result they made similar design decisions. Nicholl and McLellan (2007b) pointed out that teachers who gave attention to existing products were guiding children’s designs and as a result their design decisions were unlikely to be engaged in creative decision-making. Jansson and Smith (1991) argued that providing existing products as examples can be detrimental to design work, as features that have been pointed out as exhibiting poor design may actually be integrated into children’s designs subconsciously. Therefore the use by teachers of existing projects as examples should be made with caution.

Subject textbooks that are in use in design and technology education in Cyprus served as sources of information for children. The content of books is based on the De Vries and includes
information on different aspects of design and technology. During the post-observational interviews 9 out of 15 children (60%) said that they used their books in order to build up their knowledge before taking a design decision. From the interviews it could be seen that older children (aged 13-15) referred to their book as a source of information more frequently than younger children (aged 12-13). Fewer older children noted that they used their textbooks as a source of information in their log-books. Despite the fact that children reported that they used their books as a source of information in the interviews and log-books this evidence was not clearly supported from the observations. Only 23 out of 110 children (21%) were observed to use their books as a source of information during their design tasks. The use of teaching materials that include decision-making opportunities is supported from Barlex (2001) in Nuffield design and technology project. Nuffield books specify certain design decisions, based on Barlex (2005) pentagon of decision-making while Cypriot books are focusing on delivering information and knowledge. In that sense Cypriot design and technology books could be used as a source of information for children.

A possible explanation for the above behaviour is that during the teaching of the subject in the workshop, children had access to many other sources of information like, or they preferred to use existing projects, experiential investigations, teachers and peers that are not available during their homework outside school and as a result, the effect of books inside the classroom environment was limited. The same result was observed and discussed with the use of the internet earlier. Another reason for these results is that children did not always describe accurately exactly what they were doing in practice. Children suggested that they used their books in their interviews and log-books, but in practice this was not so frequently evident in observations. The children were probably not misrepresenting their practice deliberately, but presenting an ‘idealised’ viewpoint which is a common characteristic of the reporting of past events by humans.

Trial and error was used by children as an experiential approach to gathering information relevant to their design decisions. They used these experimental investigations in order to improve their understanding and knowledge before taking a design decision. A small number of students identified trial and error and experiential approaches as a source of information during their interviews (3 out of 15) and in their log-books (7 out of 37), but it appeared more frequently in observations (24 out of 37). A possible explanation for this outcome is that children using those experiential approaches in practice did not refer to them when asked, either because they did not consider them as proficient as other sources or because they did not realize what they
had been doing had served as a source of information. The use of trials and experiential approaches in design activities were identified from Venville, et. al. (2004) who suggested that the trials performed during class were frequently used as a source of knowledge by students and gave them critical information to make decisions about their designs.

Trial and error and experiential investigations were more used with technical and construction decisions and less frequently with aesthetic decisions. A possible explanation is that children were worried more about the technical issues and how to make correct decisions, so that their design would function properly and were less worried about the aesthetic part of their project which was considered by them to be the easier part.

Other sources that were identified by children during the research study included additional books (other than their subject compulsory book), personal interests and television. However, these did not seem to play a significant role as children’s information sources, since they referred to their use very rarely.

From the results of the study it can be concluded that children are searching from various sources of information very frequently. They used teachers as a source of information more often in comparison with other sources of information identified from the study. This outcome reflected the inability of children to find the information they needed independently and showed that they relied on the most easily accessed sources (teachers). In such a dynamic and fast changing world children need to develop the ability to search, find and assess the information they want more effectively.

**7.4.6 RQ 2b - The Effect of Age on Children’s Sources of Information**

From the literature reviewed, children’s age seemed to have an effect on their reasoning and the processes that they followed in evaluating sources of information (Davidson, 1991a, 1991b; Ford, Schmitt, Schectman, Hults, and Doherty, 1989; Klayman, 1985). The literature reviewed was focused on the effect of age on the ability of children to distinguish between relevant and irrelevant information (Davidson, 1991a, 1991b; Klayman, 1985). Very little was found in the literature on the types of sources of information that children with different ages employed as part of their decision-making process. The effect of age on the strategies that children follow in decision-making was extensively discussed previously in Section 7.2.3 as part of the decision-
making model (Figure 7.4). In this section the effect of children’s age on the sources of information they use to support their decisions is discussed.

From the results of the study (Table 7.1), it can be seen that the effect of teacher as a source of information is more important in younger age groups, aged 12-13 and less important to older children, aged 14-15. Children from age group 13-14, used the teacher as a source of information somewhere between the other two age groups (12-13 and 14-15); their use was closer to age group 14-15.

From the results as discussed above it can be concluded that for age group 14-15, the teacher remained an important source of information but was regarded as less important and was less frequently used than in age group 12-13. Older children (aged 14-15) tended to rely on additional (other than teachers) sources of information than younger children (aged 12-13) more often. A possible explanation for that behaviour is that older children (aged 14-15) developed more systematic strategies for searching information because of their experience with the learning of design and technology. Therefore, they seemed to rely more on other sources of information such as peers or their existing knowledge to reach a decision as compared with younger children (aged 12-13) who relied on teacher more often.

Peers seemed to be more important as a source of information for age groups 13-14 and 14-15, as compared to age group 12-13. For example in age group 14-15 children identified peers as sources of information in pre-observational Interview (N=5 out of 5), in post-observational interviews (N=3 out of 5), in children log-books (N= 19 out of 37) and during observations (N=23 out of 72). Peers were identified as a source of information less frequently in age group 12-13, in pre-observational interviews (N=2 out of 5), in post-observational interviews (N=2 out of 5), children log-books (N= 13 out of 37) and observations (N=10 out of 72). The effect of peers were identified earlier in Section 7.2.3 and included in the decision-making model (Figure 7.4).

The use of the internet as a source of information was found to be popular by children of all the age groups which participated in this study. From the results of Table 7.1 it can be seen that the use of internet as a source of information was almost equally important to all age groups. Children from the age of 12 were familiar with the internet and they used it as a source of information with the same frequency as 15 years old.
From the results of Table 7.1, older children (aged 14-15) appeared to rely more on their existing knowledge (N=15 out of 37) than younger children (aged 12-13) who obviously had less experience with design and technology and therefore tended to use their existing knowledge less frequently (N=11 out of 37). Similar outcomes were obtained by observing children where 35 out of 216 cases were observed to use existing knowledge to support their decisions. The use of existing knowledge appeared to increase with age; children of age group 12-13 were observed to use existing knowledge 10 out of 72 cases, in age group 13-14, in 12 out of 72 cases and in age group 14-15 it was identified in 13 out of 72 cases. The differences were small but showed the tendency of older children to rely more on their empirical knowledge. Previous research (McCormick, 2004; McNair and Clarke, 2007) identified the frequent use of existing knowledge of children during designing and that older children were using empirical knowledge more often as compared to younger children. This outcome was expected since children were building their knowledge with the experience gained in design and technology classes and they were expected to apply this knowledge to their projects as they grow older.

The number of children that reported the use of books as a source of information was almost the same in the three age groups (N=13-15-17 for age groups 12-13, 13-14 and 14-15 respectively). It seems that there are no significant differences between the age groups in the use of existing books since the use of design and technology books in the subject is part of the National Curriculum and were used compulsorily. Similarly to books the use of existing projects as a source of information did not appear to change as children grew older and it was equally important to all ages.

Older children (aged 14-15) seemed to use experiential investigations more frequently as compared to younger children (aged 12-13). From Table 7.1 it can be seen that during interviews and in their log-books younger children did not mention trials and experiential approaches in their activities as compared to older children that referred to it more often (2 out of 5 in interviews and 6 out of 37 in logbooks).

During observations researchers reported that older children (aged 14-15) used less sources of information as compared with younger children (aged 12-13). Similar results were reported from previous research studies. Davidson (1991a) found that compared with younger children (aged 6-8) older children (aged 10) searched considerably fewer alternatives as well as fewer dimensions of those alternatives. Davidson (1995) suggested that older children were more likely to eliminate unsuitable alternatives than younger children. Younger children did not
recognize relevant information and they failed to use it in decision-making tasks (Davidson, 1995). Davidson’s research studies (1991a and 1995) were with younger children but from the results of the study it can be seen that this behaviour is possibly continued as the children grow older between the ages 12 to 15.

From the results of the research, it can be concluded that children’s ages play a significant role on the type and the frequency of sources of information that they use. Older children (aged 14-15) are using different sources of information more frequently (mainly peers, trial and error and existing knowledge) as compared to the sources of information (mainly teachers) used by younger children (aged 12-13).

7.4.7 RQ3 - Difficulties that Children Face in their Efforts to Make Decisions

Literature reviewed (Barlex and Miles-Pearson, 2008; McCormick, 1999; Nicholl and McLellan, 2007b) identified various difficulties that children faced in their effort to take their design decisions. Barlex and Miles-Pearson (2008) found out that when the pupils were given the chance to express themselves freely in their design projects they faced difficulties in making design decisions due to their lack of experience. While Nicholl and McLellan (2007b) suggested that children make design decisions that lead to very stereotypical features of an object and this difficulty is partly because of fixation.

The research study also identified some difficulties that children faced in their efforts to take their design decisions. The main difficulties that were involved in children’s decision-making strategies were discussed extensively previously in Section 7.2.3 at part of the decision-making model (Figure 7.4). This section will summarise and discuss further those outcomes. The main difficulties identified from Section 7.2.3 are summarised as follows:

- Children faced difficulties in searching for relevant information for their decisions. As a result they relied mainly on teacher as a source of information.
- Children had difficulties in specifying evaluation criteria for their design decisions. They usually considered only attractiveness.
- Children were unable to handle multiple evaluation criteria for their design decisions.
- Sometimes children showed lack of confidence in reaching a decision.
- Children could not understand that a design decision taken might have an effect on forthcoming decisions for the same design.
- In some cases, children showed lack of motivation during decision-making.
The difficulties that children faced during decision-making in design and technology education could have been affected by various factors. A possible reason could be that children might not have the capabilities to handle as complicated tasks as the teacher required from them. Therefore further research on that area could provide useful information.

The difficulty children had in searching for relevant information (especially children aged 12-13) in order to gain the required knowledge to take their decisions and their difficulty in specifying and handling evaluation criteria for their design decisions could be partly a result of non-formal teaching on how to search effectively relevant information. Baron et al. (1993) suggested that schools must provide special programmes for the enhancement of decision-making abilities, as with many other logical abilities. Similarly, Mettas et al. (2008) suggested that “associated formal training in decision making techniques might ‘improve the quality of children’s decisions during design activities” (p.68).

The results of the study identified difficulties associated with lack of confidence and lack of motivation in decision-making. The lack of confidence deserves further consideration with further research studies. Lack of motivation could be a result of non-meaningful teaching activities or tasks that are not linking design and technology with real world contexts (McCormick, 2004; Jones, 2003).

The results of the study suggested that children usually failed to relate a design decision already taken with a decision that will follow. For example, deciding the type of mechanism that they will use for their car model project (e.g. gears), might affect the distance between the driven and the driver gear and as a result the dimensions of their car model. Very little was found in the literature on that specific difficulty and there is a need for further research in order to investigate possible reasons for that behaviour.

7.4.8 RQ 3a -The Ability of Children to Develop Criteria for Evaluating Options

The literature reviewed suggested that some decision-making situations deserve careful thought (Bazerman, 2005; Clemen, 1991; Hammond et al., 1999). In those cases decision makers identify relevant evaluation criteria that will be used in order to assess their available options and based on them make their decisions. Children reported various criteria during their engagement with the design activities set to them as part of the research study.
From the research study, various criteria that children generated for evaluating their options were identified. Table 7.2 is presenting the evaluation criteria that children identified from the analysis of the various data collection instruments.

<table>
<thead>
<tr>
<th>Data Collection Method</th>
<th>Evaluation Criteria</th>
<th>Frequency Used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12-13</td>
</tr>
<tr>
<td>Post-observational Interview (N=15)</td>
<td>Attractiveness</td>
<td>2</td>
</tr>
<tr>
<td>(5 in each age group)</td>
<td>Time Limitations</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cost of their design project</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Strength</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Functionality</td>
<td>1</td>
</tr>
<tr>
<td>Children Log-books (N=110)</td>
<td>Attractiveness</td>
<td>24</td>
</tr>
<tr>
<td>(37 in each age group)</td>
<td>Time Limitations</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Cost of their design project</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Functionality</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Easy to make</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Materials availability</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Personal interest</td>
<td>9</td>
</tr>
<tr>
<td>Observations (N=216)</td>
<td>Attractiveness</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Time Limitations</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Functionality</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Cost of their design project</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Strength</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Ergonomic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Materials availability</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 7.2- Children evaluation criteria identified from the main research

Based on the results of Table 7.2, attractiveness seems to be the most frequent criterion that children are using to base their decisions on. In post-observational interviews 6 out of 15 students used the attractiveness as a selection criterion and 56 out of 110 in their log-books. In the pre-test and post-test, when children were asked to take a decision about which phone to buy or which design idea to choose, attractiveness was the most important criterion for both cases. Attractiveness turned out to be important during observations, but not as important as time limitations. A possible explanation is that when children were designing their products they were worried about the available time they had to finish their project, but when asked before or afterwards during the interviews they considered attractiveness as being more important. The explanation for this behaviour could be that in many design projects there are more options available to them in terms of aesthetics as compared to other issues such as technical or constructional decisions where there are usually less available options to consider. In addition in their design projects, attractiveness was considered to be very important for their personal
decisions as well. Aesthetics were also considered by Barlex (2005) as a criterion of design decision-making in design and technology education that is used very often.

Time limitations were also a factor that affected children’s decisions in design and technology. From Table 7.2, it can be seen that children acknowledged that there were time limits within which they had to finish their design work. During the observations, children were seen to be discussing time limitations. For example, a participant observer noted: “children were always worried about the time they had and the possibility to leave part of their project incomplete”.

There are always time limitations in the school environment. Lessons need to start and finish within specific time ranges. This seemed to affect children’s behaviour during the designing and making of their projects. Children seemed to be worried about their available time to complete their design projects and considered ‘working within the time limitations’ as one of their decision-making criterion. It is possible that this behaviour affected the strategies that they employed to reach their design decisions. These findings further supported the idea of Clemen (1991) who argued that there are cases where, because of time limitations the use of analytical reasoning processes is not always feasible and the decision-maker follows other simplified techniques, which thereby affect the outcome.

From Table 7.2, it can be seen that the cost of their design project did not seem to be an important issue for children during their engagement with their design task. A possible explanation for that behaviour is that children do not have to pay for the materials or equipment they used in schools. The school provided the materials and equipment for them free and as a result they did not appreciate enough the importance of the cost for their designs. In contradiction, from Table 5.4 it can be seen that they considered the cost to be a very important criterion when the outcome of their decision was a personal purchasing item, for example a mobile phone. In that case they (or their parents) had to pay for their personal purchasing. Teachers needed to emphasise this issue in a way that children will appreciate more the importance of the materials they used in schools.

From the results of Table 7.2, it can be seen that the strength of their final product was considered to be a significant issue for children. Children identify during their interviews that they prefer to design and make a product that is strong enough and they employ construction techniques to achieve that. This type of criterion is related with Barlex’s (2005) constructional decisions as proposed from his design decision pentagon.
From the results it can be seen that children considered the proper functionality of their products to be an important issue. Children's design decisions considered ways in which to establish the proper function of their design. This type of criterion is relevant to technical decisions as proposed in the design decisions pentagon (Barlex, 2005).

Materials’ availability was also reported as a criterion for their design decisions. This factor was also considered by Trebell (2011), as one important area in which children could take design decisions. Other criteria that were identified from children, but less important based on the results, include personal interest, ergonomic issues and the difficulty or ease of making.

From the results of the study, a number of criteria that children used to evaluate their design decisions were identified. Although children mentioned evaluation criteria for their design decisions in their interviews and log-books, the actual application of them in observations were not so evident. A possible explanation for that outcome is that children said that they were using criteria to evaluate their available options as part of the assessment requirements but when observed in practice the existence of evaluation criteria was limited. The most frequent criterion that they used was the attractiveness of their designs. The results indicated that children did not always generate criteria for their decisions, they relied more often on heuristics approaches and they used their existing knowledge in order to evaluate their options (Clemen, 1991; Gigerenzer, 2001; Stanovich and West, 2000).

7.4.9 RQ3b – The Effect of Age to the Ability of Children to Specify Evaluation Criteria

The effect of children’s age on their decision-making strategies and the sources of information they used was extensively discussed in Section 7.2.3 and Section 7.4.6 respectively. From the literature reviewed, there was a significant gap on the effect of age on the type of evaluation criteria that children use. From the results of this study, age seemed to have an effect on the types of evaluation criteria that children reported. In some cases, older (aged 14-15) and younger (aged 12-13) children were observed to use different criteria on which to base their decisions.

From Table 7.2 it can be seen that attractiveness as an evaluation criterion did not seem to be equally important for all age groups. Younger children (aged 12-13) seemed to consider the attractiveness as an evaluation criterion more frequently than older children (aged 14-15) did. In their log-books 24 out of 37 children at the age of 12-13 reported attractiveness as a criterion in
a comparison to 14 out of 37 children aged 14-15. Similar results were identified from observations. Younger children were observed to discuss attractiveness 21 times as compared to 10 times where it was mentioned by older children’s.

Time limitations were identified to be used more often by older children (aged 14-15) as compared to younger children (aged 12-13). It seemed that the older children were more experienced and were able to handle their time more effectively as compared to the younger children’s who are more inexperienced and cannot estimate the time needed for the completion of their projects so effective.

The findings of the study in relation to the effect of age on the use by children of evaluation criteria indicates that older children reported more technical issues such as functionality and time limitations as evaluation criteria as compared with younger children who considered the attractiveness as the most important criterion for their decisions. The use of different criteria by older children as compared with younger children can be distinguished from the outcome found in Section 7.4.6, which suggested that older children used different sources of information than younger children. In his research study Davidson (1991a) suggested that older children (aged 10) used more systematic and effective decision-making processes as compared to younger children (aged 6-8). The differences that were identified from the study on the types of children’s criteria in relation to their age could be a result of this more systematic reasoning that Davidson (1991a) suggested.

7.4.10 RQ4 - The Extent to which Decision-Making Skills learnt within the Area of Design and Technology are Transferred to Other Activities

The learning activities that teachers set to children in schools, and the skills that children develop as a result of this experience are expected to be transferred to other areas of life. Despite this statement being an ambition of educational systems, from the findings of this study and from the literature reviewed (Givens and Barlex, 2001; Glaser, 1992; McCormick, 1999) it turns out that the existence of such transfer from one domain to another domain is not clearly evident.

The ability of children to transfer skills from one domain to another domain was discussed in detail in Chapter 7.2.3. From the results of the study most children reported in their log-books
(Table 5.15) that a design decision taken for their project will not have an influence on a decision that will follow in the same project (74 out of 110).

This finding was unexpected and suggested that the transfer of skills is difficult even within the same domain (design and technology in this case). According to Givens and Barlex (2001) design and technology education seeks to teach a set of generic design skills in such a way that they become transferable within the different areas of the subject. The related literature on transfer of knowledge and skills suggests that transfer is not easy (Hennessy and McCormick, 1994; Levinson et al., 1997; and McCormick, 1999).

Barlex (2005) proposed five areas in which children are required to make design decisions (Figure 2.2). From the analysis of those five areas Barlex and Trebell (2011) argued that a change of decision within one area will affect some if not all of the design decisions made within the other areas. The findings of the current research study suggested that such a relation is difficult for children to understand.

During their interviews children expressed the belief that what they are learning in schools was not directly related to what they were doing in other activities of life. This outcome is important for further research in order to understand the reasons why children cannot relate school activities to their home activities. A possible explanation for this might be that teachers set children activities that are not meaningful to them and do not relate the school classroom with the real world. This idea is supported from other researchers, Fox-Turnbull (2006) suggested that an important issue about the nature of activities that children undertake is that authentic learning engages children and encourages learning. According to Hennessy and Murphy (1999) an “activity is said to be authentic if it is (i) coherent and personally meaningful and (ii) purposeful within a social framework – the ordinary practices of culture” (p.8).

During the pre-observational interview (before the task) children described how they take decisions in design and technology and also in their personal life. As described earlier in Table 5.4, children considered the cost for their personal purchasing as an important criterion for their choices (9 out of 15) but at the same time only 1 out of 15 children considered cost as a criterion that will affect the decision that he/she will take for his/her design project. From those findings, it can be suggested that children cannot relate the decisions taken in their design and technology projects with their personal decisions and vice-versa.
This difference in specifying criteria for their design decisions might have been a result of the difficulty in relating and connecting school activities with other personal activities outside schools. This behaviour might also have been a result of children’s lack of motivation to do so (McCormick, 2004). Children do not spend time and effort on their design and technology decisions. However, their personal decisions are more important for them and therefore they are more motivated to think more carefully about their possible options and the criteria that their desired choice will have to meet (Klaczynski et al., 2001).

The results of the study suggested that decision-making skills learnt within the area of design and technology education are mainly domain specific and difficult to be transferred to other activities. However, more research on this topic needs to be undertaken for the possible transfer of skills within and outside the same domain in a way that the relationship between transfer of skills and decision-making activities is more clearly understood.

7.4.11 RQ4a – The Effect of Design and Technology on Children’s Capabilities in Making Decisions in Situations Such as Personal or Social Dilemmas

Butterfield and Nelson (1989) suggested that promoting transfer is the fundamental goal of teaching, because contexts and purposes change, and people are severely handicapped if they do not adapt their past learning to new circumstances and intentions. Learning in design and technology on how to make design decisions could have possible effects on how children make decisions in other situations such as personal or social dilemmas.

Davies (2004) argued that children’s design decisions play a significant role in developing their understanding of the relationship between technology and society. This relationship between technology and society might include decisions in situations such as personal or social dilemmas. Prime (1993) identified the relationship between technology practice and society and suggested that “it is only an informed and technologically literate citizen who would be able to make decisions about technology and assess its broad social impact on family structure, inter- and cross-cultural relations, national and international functioning, its economic impact on business, commerce and government, as well as its environmental impact on agriculture, food production, and waste disposal, in both the short and long term” (Prime, 1993, p. 32).

From the results of the study in Table 5.6 it can be seen that 7 out of 15 children reported during their interviews that school does not give them decision-making opportunities to improve their
skills in other areas of life. For example, a child said during the interview: “what we have learnt in school cannot be directly applied to other areas of life outside schools”. During the interviews, only 3 out of 15 children expressed the belief that school offered them opportunities to improve their decision-making skills. This finding was unexpected and suggested that in many cases schools failed to offer children meaningful activities that link the classroom environment with the real world context. The importance of the use of such activities in design and technology education has been identified in previous research (Fox-Turnbull, 2006; McCormick 2004).

The finding that children do not relate classroom activities with other situations such as personal or social dilemmas was also supported from Table 5.7 which summarised the outcomes of pre-observational interviews. From the results it can be seen that all children that were asked (N=5) at the age of 12-13 reported that they do not believe that they transferred skills from design and technology education to other areas of life (5 out of 5). A small number of children (2 out of 5) at the age of 14-15 reported that in some cases they were able to transfer skills from the subject of design and technology to other areas of life.

This finding supports previous research (Carraher and Schliemann, 2002; Gagne et al., 1993; McCormick, 2004) into this area that suggested that the transfer of skills from one domain to another is complicated and is not clearly evident from research studies. From the results of the current study it can be seen that children at the age of 14-15 reported some responses that relate the decision-making skills learned in design and technology with decision-making in other areas such as personal decisions.

The pre-tests and the post-tests that were used in the research study consisted of 2 tasks. The first was related to a social dilemma, in which children had to decide about the best location to build up a new power station, and the second task was related to a personal purchasing decision, which required children to decide which phone to buy among the 3 phones suggested to them. The pre-tests and post-tests were administrated to children before and after the design task was given to them.

From the analysis of the pre-tests and post-tests it emerged that in the case of the first task, (the social dilemma), children made a decision mainly based on the criterion that they considered to be the most important criterion for them (Table 5.23). The results indicated that children faced difficulty in considering all the criteria given to them and it was much easier for them to base their decision on the criterion they considered to be the most important one. In the post-tests
children’s responses were slightly changed, considering all criteria given to them more frequently as compared to the pre-tests. The differences in the responses from pre-tests to post-tests were very small and therefore cannot give a clear indication on the changes of children’s strategies before and after the design task given to them (the differences can be seen in Table 5.23).

In the case of the second task (personal purchasing dilemma) children were more able to consider a number of criteria and not only the criteria that they considered to be the most important (Table 5.26) as happened with task 1. From the results, 49 out of 110 children in pre-tests and 54 out of 110 in post-tests considered all criteria before taking a personal decision on which mobile phone to buy. Corresponding results for the social dilemma task showed that only 16 out of 110 children in pre-tests and 19 out of 110 in post-tests considered all criteria before taking a decision. This outcome suggested that during personal decisions children are more able to handle multiple criteria as compared with decisions in social dilemmas. Possible explanations for this could be that children are usually more familiar with personal decisions as compared with social decisions and/or children are more motivated to explore more detailed dimensions of their personal decisions than of social decisions.

From the results of the study, it can be suggested that experience in design and technology does not seem to have a significant effect on children’s capabilities in making decisions in other situations such as personal or social dilemmas. The small differences that occurred from pre-tests to post-tests might be a result of the design task given to children, but could also be affected by many other factors, since a number of other activities and events had happened in the children’s lives during that period inside and outside school. Therefore, these results should be treated very carefully and are just an indication of how children changed their decision-making strategies after their design task.

Based on the results, there was also no evidence to support children’s transfer of skills from activities outside school to design and technology. Although many children were able to define detailed evaluation criteria for their personal decisions such as buying a mobile phone, they faced difficulties in specifying evaluation criteria for their design decisions. This might be affected by the lack of motivation to spend time designing or by the complexity of the design tasks that the teachers required from children.
7.4.12 RQ4b – The Effect of Age in Children’s Ability to Transfer Decision-Making Skills in Personal or Social Dilemmas

The effect of age in children’s decision-making capabilities was explored in detail in Section 7.2.3. In this Section the effect of age in relation with the abilities of children to transfer decision-making skills in personal or social dilemmas will be discussed.

From Table 5.6 it can be seen that older children (aged 14-15) are more likely (2 out of 5) to recognise the relation of school activities with other activities in their everyday life as compared with younger children (aged 12-13, 0 out of 5). This outcome is giving an indication that age had little effect on children’s abilities to transfer skills from one domain to another. These findings must be interpreted with caution because it is an outcome mainly from children’s interviews that was not observed in practice and therefore there is a possibility that it is not valid. Sometimes, children do not always describe accurately what they are actually doing in practice. In addition, because of the small sample size, caution must be applied, as the findings might not be generalised.

The research study identified that as children grow older (from 12 to 15) they are more able to relate a decision made for their design project with decisions that follow in the same design project. From the results of Table 5.15, it can be seen that 29 out of 37 younger children (aged 12-13) reported that a decision already taken in their project will not affect their next design decisions in the same project. The results of older children (aged 14-15) are suggesting that they were more able to consider that a design decision taken could affect their next decisions. From Table 5.15, it can be seen that 19 out of 37 older children believed that one design decision is related to others as compared to younger children, where only 8 out of 37 reported that next decision might be affected from design decisions already taken.

The ability that some children showed to predict the effect of one decision on another is a small indication of their ability to transfer skills from a certain situation to another. Givens and Barlex (2001) also argued that design and technology education seeks to teach a set of generic design skills in such a way that they become transferable from one area of design and technology to another. For example pupils who learnt a particular design skill (e.g. developing specifications) when they are working with textiles are able to access and use the skill appropriately when working at some later time e.g. with systems and control (Givens and Barlex, 2001). An indication of the ability of children to transfer skills within design and technology could also be
seen when children were using their existing knowledge in order to reach a decision (McCormick 1999). This suggests that children are somewhat able to transfer their skills from one design project to the other and this outcome is more evident for older children (aged 14-15).

From the findings of the study, there was not any significant evidence to support that the skills that developed in design and technology education are directly transferred to other decision-making cases in areas such as personal or social dilemmas. Older children seemed to be more able to relate design decisions with their personal decisions as compared to younger children but the differences were too small to be generalised. Further research in that area is required in order to investigate the effect of age on the ability of children to transfer skills.

7.5 Discussion of Results in Relation to other Outcomes that Emerged from the Study

From the results of the research study some additional outcomes emerged that were not directly relevant to the research questions. Such results were mainly obtained from observations and are discussed in the following sections.

7.5.1 Children Engagement and Classroom Activities

During the observations researchers reported that different classroom activities were affecting children’s engagement and interests in the learning process. Children were observed to indicate different degrees of engagement and interest during the learning process as a result of different classroom activities. Table 7.3 presents the children’s engagement during the design task in relation to the classroom activities.

<table>
<thead>
<tr>
<th>Children Engagement and Interest</th>
<th>Classroom Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lecture</td>
</tr>
<tr>
<td>Low</td>
<td>11</td>
</tr>
<tr>
<td>Moderate</td>
<td>6</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.3 - Student engagement and interest vs. classroom activities
From the comparison (crosstabs using SPSS version 17) of classroom activities against student engagement and interests (Table 7.3) it can be seen that when the classroom activity was 'lecture' children showed low engagement and interest in the learning process. This outcome was expected since children are not directly active during lectures. Children indicated higher engagement in their design tasks when they were working with hands-on activities, during class discussions and when the teacher was circulating while children were working individually. Moderate engagement in their design task was observed while teachers were demonstrating and when a lecture/discussion was taking place.

Based on the above outcome it can be suggested that the design of curriculum or teaching materials needs to be based on the classroom activities that enhance children’s engagement in the teaching and learning. This learning by hands-on/discovery is supported by Piaget, Vygotsky and Bruner’s theories and provides opportunities for learners to explore and experiment, thereby encouraging new understandings (Brainerd, 1978; Vidal, 1994).

### 7.5.2 Children’s Engagement and Sources of Information

From the analysis of the observations it can be seen that different sources of information enabled different degrees of children’s engagement in their design tasks. Table 7.4 is presenting the children’s engagement during the design task in relation to the sources of information.

<table>
<thead>
<tr>
<th>Children Engagement</th>
<th>Sources of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher</td>
</tr>
<tr>
<td>Low</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>31</td>
</tr>
<tr>
<td>High</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 7.4 - Student engagement vs. sources of information

The higher engagement of children was presented during hands-on activities like trial and error and other explanatory investigations. This outcome was expected since children were trying through these activities to investigate and develop the knowledge and skills needed for their
design work. High engagement of children was also observed when children were using their existing knowledge in order to take their design decisions. Moderate engagement of students was observed when children were using as a source of information such as their subject book, teacher, internet, peers and existing projects.

The results of the study suggested that there were various sources of information relevant to teaching and learning in design and technology. Children usually used teachers as a source of information and this did not involve them in high engagement with the learning process. The effect of this phenomenon depended on how the teachers handled such situations in practice and there was a need to encourage their pupils to search for the information they needed from more challenging sources and not give them the information directly that they can find alone.

7.5.3 The Balance of Control between Teacher and Pupil

Based on the results of observations (Table 5.16) a graphical representation that describes the teacher and children interactions during the design project were designed (Figure 5.4). The interactions were considered to be either 'teacher predominantly in control' or 'teacher and children equally in control' and 'children predominantly in control', similar to Stables (1995) study. Stables (1995) investigated Year 7 (aged 11-12) interactions in practice and she concluded that there was a gradual shift from the case of the teacher initially being in charge of the project (through direction); through an intermediate phase where pupils start to take control; to a final point where pupils were taking the majority of decisions. The classroom interactions as observed by Stables (1995) were presented graphically earlier in Figure 2.8.

This study produced results which corroborated the findings of a great deal of Stables (1995) work in this field. From the results of this study, as presented in Figure 5.4 (Chapter 5) it can be concluded that at the beginning of the design project the teacher was mainly in control of the learning and the design decisions. After that there was a period where the interactions were more complicated with many of interactions taking place, 'mainly teachers in control', 'teachers and children equally in control', and 'mainly children in control'. During that period teachers and children equally in control were more dominant than the others. At the final stages of the design project there was a stage that children were mainly in control of their learning and their design decisions. The results did not indicate any significant differences in terms of age.
Summary

The findings of the study have been discussed in relation to the literature reviewed. Based on that analysis a theoretical model was designed which proposes a number of factors that are involved in children’s decision making processes within design and technology education. The factors included in the model were: knowledge, skills and values, the national curriculum, teachers own ideas and how they implement the curriculum, children’s strategies, difficulties, their age, peers and the ability to transfer skills from other areas. A discussion of the results in relation to the research questions has also been conducted. Additional issues that emerged from the study were also discussed as part of this chapter.
Chapter 8: Conclusions

Overview: This Chapter is discussing the conclusions and the implications that emerged from the research study. The contribution of the research findings to new knowledge is pointed out and suggestions for further research are also identified.

8.1 Conclusions and Implementations

The purpose of the current study was to explore children’s decision-making behaviour in design and technology education in Cyprus. More specifically the aim of the study (as presented in section 1.4 earlier) was to investigate the teachers’ role and the effects of curriculum materials in children design decision-making, the strategies that children followed to reach a design decision, possible problems they faced, sources of information they used to support their design decisions and their ability to transfer those skills to other activities of life. Returning to the aim and the research questions posed at the beginning of this study, it is now possible to state that the aims of the study were achieved through the findings of the study. The most important conclusions that emerged from the study are summarised below.

Responding to the above general aim and the research questions resulting from this, this study has led to the development of a model that describes the factors involved in children decision-making in design and technology education. This study has also explored the use of various decision-making strategies by children aged 12-15 year old and it has led to a greater understanding of the difficulties that children face in their efforts to take their design decisions.

The emerging model of the factors involved in children decision-making in design and technology education for children aged 12-15 years includes the following eight factors: i) children's knowledge, skills and values, ii) the national curriculum, iii) teachers' own ideas and how they implement the curriculum, iv) children's strategies, v) children's difficulties, vi) children's age, vii) peers and viii) the ability to transfer skills from other areas. Based on the results of the study it can be concluded that the outcome of design decisions is usually the result of the interaction between children and the teacher along with other factors that are included in the decision-making model (Figure 7.4) such as existing projects or peers etc. Based on the model it can be concluded that decision-making is a complex process and in practice the inexperienced children were usually taking those decisions with the influence of many factors.
Therefore policy makers and curriculum developers need to treat decision-making as a model and not considering the factors independently. Any teaching intervention that aims to improve children’s decision-making skills needs to consider all factors that are included in the decision-making model (Figure 7.4) and teaching resources and teaching strategies need to be designed that include all factors as a group and not each one individually.

The strategies that emerged from the research study and the theoretical model are summarized below: Whenever children needed information in order to take their design decisions they tended to use teachers as a source of information and sometimes expected teachers to suggest a decision for them. Children were specifying some criteria that the decision needed to fulfil and took their decision based on those criteria. Criteria were usually related to their values, interests, or their available time. Frequently children followed simplified processes such as trial and error and rules of thumb and using their existing knowledge in order to reach a design decision. Older children (aged 14-15) took quicker decisions and use less sources of information before taking a decision as compared to younger children (aged 12-13).

The findings of the study also suggested that children faced various difficulties during their efforts to take their design decisions. Some children were unable to search for relevant information and they mainly depended on the information given by their teachers. Another problem that children faced was the difficulty in evaluating their possible options for their design decisions. Children usually took their design decisions based on aesthetic factors rather than having considered other features of the product as well. Some children reported lack of confidence in taking a design decision. These findings could be partly explained by the limited experience that some children had in design and technology. Moreover, the results of this study suggested that children faced various difficulties in relating those decisions together. The findings of the study suggested that as children grow older (from 12 to 15) they were more able to relate a decision already made for their project with decisions that followed in the same project.

These results lead to the conclusion that children do not necessarily follow a systematic approach with ‘logical steps’ before taking a decision and they usually rely on heuristics approaches using their existing knowledge as built from previous work with design projects to take a decision. Teachers should therefore scaffold the use of a more systematic decision-making approach by the students, interrogating them about their decisions and helping them reflect on the alternative choices they may select for their project’s realisation and helping them...
explore their relevant advantages/disadvantages. Teachers also need to help children use various sources of information and encourage them to differentiate relevant from irrelevant information and to use the knowledge gained in order to support their design decisions.

The results of the study identified various types of design decisions that children followed during the investigation. A number of conceptual decisions were made by children, which were mainly about the purpose of their designs. Technical, aesthetic and constructional decisions were also considered to be very important by children. Other types of decisions that emerged from the findings of this study were related with the material selection, safety issues, and the management of their available time.

From the findings of the study it can be concluded that age differences might affect children’s decision-making strategies in design and technology education. From the results it can be concluded that older children who participated in the study (aged 14-15) searched for less sources of information before taking a design decision as compared to the younger children of the study (aged 12-13). Younger children usually used teachers as a main source of information or existing projects where older children rely more on their peers, the internet and experimental techniques. The research findings also showed that older children were more able to define a number of criteria through which to evaluate their alternative options before taking their design decisions. Older children (aged 14-15) referred to more technical criteria such as functionality and time limitations as compared with younger children (aged 12-13) who considered the attractiveness to be the most important criterion for their design decisions.

The evidence from this study suggest that differences in likely decision-making strategies exist in design and technology education and teachers should be aware of them when designing learning activities for their pupils in different age groups. Teachers need to help children to use various sources of information and encourage them to differentiate relevant from irrelevant information and to use the knowledge gained in order to support their design decisions.

This study confirms also that the transfer of skills is mainly confined to a specific domain and that it is difficult for them to be transferred from one domain to another. Most children in this study specified detailed criteria for their personal purchasing choices, but at the same time very few children considered evaluation criteria for their design decisions in the project given to them. Based on that evidence it can be concluded that children do not relate their design decisions taken in design and technology with their personal purchasing decisions. The study provided also evidence to support that children are more able to handle multiple evaluation criteria for
their personal decisions as compared with their design decisions in design and technology education, while they experience lack of motivation and confidence during decision-making in design and technology education. Moreover, the study results indicated lack of motivation by children in decision-making in design and technology education. When children were asked about taking a personal decision (e.g. buying a mobile phone) they were more able to specify detailed evaluation criteria and search for various sources of information to support their decisions as compared to their design decisions during the project. From the results, it can be concluded that during the design project most children rushed to take their decisions without any prior investigation or exploration of possible options.

At the same time transfer from activities outside school into design and technology classes was also not evident from the results. From the findings of the study it can be suggested that experience in design and technology does not seem to have a significant effect on children’s capabilities in making decisions in other situations such as personal or social dilemmas. Children were able to specify detailed evaluation criteria for their personal decisions but at the same time were unable to do the same with their design projects. This outcome could have many explanations, such as lack of motivation for design decisions or the content of design tasks not having been meaningful or interesting for children.

These findings lead to the conclusion that the knowledge transfer from the design and technology classroom to everyday life shall not be taken for granted. Teachers need to establish connections between decision-making activity in the design and technology class and decision making activity in everyday life. Children should be encouraged to become more actively engaged in the classroom and can learn to work successfully in groups to address decision-making problems. Moreover, children can extend their learning beyond the classroom as they apply their decision-making skills to real-world problems. Decision-making skills can be introduced successfully in a broad range of classroom settings in design and technology education and in a way that gives the opportunity to children to become active and creative decision-makers.

This conclusion is supported further by the results of this study, which indicated that different classroom activities stimulated different degrees of student engagement in the learning process. From the results it can be seen that when a lecture (teacher giving a whole class explanation) was taking place children showed lower engagement in the learning process and when hands-
on activities and class discussion was taking place in the class children showed higher engagement in the learning process.

One of the more significant findings that emerged from this study was that children used their teachers as the most frequent source of information that they needed for their design decisions. Therefore teachers need to be careful during teaching and learning and act as facilitators for learning, helping children to acquire the knowledge themselves and not serve as a source of information for children (unless of course that is their intention in order to facilitate other learning objectives).

The evidence from this study has also suggested that teachers have an important role in the teaching and learning of children’s decision-making skills. The types of design decisions and the opportunities that teachers offer to children have an effect on children’s decision-making strategies. In addition teachers’ ideas about teaching and learning, teacher beliefs, teachers’ implementation of the curriculum and the teaching resources used all affected the classroom learning environment and children’s interests in the learning process and as a result their engagement in decision-making.

The study has additionally provided evidence about the effect of the curriculum requirements on the decision-making opportunities that teachers offer to their pupils. The results of the investigation also suggested that the requirements of curriculum materials play a key role in the development of decision-making opportunities within design and technology education. These findings underline the role of the curriculum and the role of the teaching resources in the enhanced use of decision-making opportunities in the design and technology class. It can be therefore be concluded here that the design and technology curricula should emphasize the provision of decision-making opportunities and children’s active involvement in the decision-making process, to help teachers incorporate decision-making opportunities in their goal setting and in their lesson plans. Furthermore, curriculum designers must ensure that teaching materials include various opportunities and activities for children to explore their decision-making skills.

The findings of the research study identified information relevant to the research questions and the aims and objectives of the study achieved in great extent. The outcomes of the research are giving useful information on children’s decision-making behaviour in design and technology education. The results provides guidance for the design of learning environment that supports
the enhancement of decision-making skills and supports that a successful decision-making teaching is important to consider the contribution of all factors identified from the research such as teachers, children capabilities and curriculum requirements.

8.2 Research Study Contribution to Knowledge

The research findings improved our understanding on the factors that are involved in children’s decision-making in design and technology education. The contribution to knowledge from this research study includes:

1. The development of a model that explains the factors involved in children decision-making in design and technology education.
2. The various decision-making strategies that children follow in order to take their design decisions.
3. Greater understanding of the difficulties that children faced in their effort to take their design decisions.
4. Children shown lack of motivation and confidence during decision-making in design and technology education.
5. Teacher confirmed to be a significant and frequent source of information for children’s decisions.
6. Teachers own ideas, pedagogical knowledge and teaching resources they use are affecting the development of children decision-making capabilities.
7. Evidence to support that children are more able handle multiple evaluation criteria for their personal decisions as compares with their design decisions in design and technology education.
8. The requirements of the curriculum have an effect on the decision-making opportunities that teacher offers to their pupils.
9. Confirmation that the transfer of skills is mainly specific domain and is difficult to be transferred from one domain to another.

8.3 Further Research

This study added to the limited research on how children take their design decisions by investigating the factors that are involved in children’s decision-making behaviour in design and technology education. From the findings of the research study many issues emerged that needs further investigation. The most important of them are listed below:
Interactions between the factors that are involved in the model for factors affecting children’s decision-making in design and technology (Figure 7.4)

The factors of children’s decision-making model in design and technology education as presented in Figure 7.4 have relationships and interactions between them. Those interactions might affect children’s design decision-making processes and any change in one factor is possible to have an effect on the other factors as well. The importance of each factor and its contribution in children’s decision-making capabilities and the interactions between them needs further investigation.

Heuristics in design and technology education

The findings of this study identified a number of heuristics and simplified strategies that children follow in order to take their design decisions. Further research is required to examine in depth the effects and the types of heuristics approaches that are in used in decision-making in design and technology education.

The influence of peers to the children teaching and learning

From the results of the study peers seem to have an important role as a source of information that affects children’s design decisions in design and technology. The effect of peers in children’s decision-making requires further research in order to understand the types of decisions that are affected more from peers in the area of design and technology education.

Pupils trust or do not trust information from the internet

The degree to which pupils trust or do not trust information from the internet is another issue that needs to be addressed. Many children in that study used the available information from the internet without trying to confirm the accuracy and the validity of the information. This could lead to wrong judgments and as a result bad decision-making, not only in technology projects but in everyday activities as well.

Transfer skills from design and technology education to other areas

The results of the study indicated that decision-making skills learnt within the area of design and technology education are mainly specific domain and are difficult to be transferred to other activities. However, more research on this topic needs to be undertaken for the possible transfer
of skills within and outside the same domain in a way that the relationship between transfer of skills and decision-making activities is more clearly understood.

- **The effect of age in the ability of children to transfer skills**

  From the findings of the study older children seem to be more able to relate design decisions with their personal decisions as compared to younger children’s, but the differences were small to be generalised. Further research in that area is required in order to investigate more the effect of age in the ability of children to transfer skills.
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Appendices

Appendix 3.1: Pilot Study Design Task (The Moving Picture)
Appendix 3.2: Pilot Study Log-books example (maybe is the moving picture)
Appendix 3.3: Main Study Observation Protocol
Appendix 3.4: Main Study Pre-observational Interview Protocol
Appendix 3.5: Main Study Post-observational Interview Protocol
Appendix 3.6: Main Study Decision-Making Task
Appendix 3.7: Pilot study Pre-test and Post-test
Appendix 4.1: Main Study Pre-test and Post-test
Appendix 4.2: Main Study Log-book
Appendix 3.1: Pilot Study Design Task Set to Children

Introduction
The design of a moving picture could be a valuable learning experience for children. Children will compose the picture themselves and identify parts of the picture that could move. This develops their sense of the narrative embedded in the picture. The production of a picture with moving parts will provide the children with enjoyable and powerful learning experiences with simple mechanism like levers and linkages.

Design Task
Your task is to design and make a simple moving picture using levers and linkages. The moving picture will be constructed using Corriflute (type of soft plastic) as the main material. You can also use simple materials to decorate your moving picture. The moving picture could be used to decorate your room, or to give it as a gift to a friend that he is in hospital. You’re first task is to think of an occasion that the design and make of a moving picture will be useful.

It might be as a decoration to your room

It might be a gift to a friend that is in a hospital
Design Decisions

During the design and the construction of your moving picture you will require taking some design decisions. Your design decisions will ensure that the final result will be a construction of a moving picture based on your personal preferences.

The design decisions that you might take are:

- What the moving picture will be about;
- What images the moving picture will contain;
- Which parts of the picture will move;
- The suitable type of mechanism that will give the desirable movement;
- Additional features for the decoration of the picture;

![Figure 1. Example of a moving picture using levers](image)

It is important to understand that some of your design decisions might have an influence on other design decisions that follow. For example, the moving parts of the picture will have an influence on the type of linkage that will be used.
The Theme of the Picture

At this stage you should choose the theme of your moving picture. For example, you can create a figure that represents an animal able to move his ears. You can also design a moving picture with two airplanes flying to the same or opposite direction.

You can get ideas from the natural or technical environment

Pictures from the Natural Environment

Pictures from the Technical Environment

You also need to decide about the moving parts of your picture. For example, if your picture represents an animal, the moving parts might be the ears or legs. You may also decide to move the whole figure within one background, for instance a car that is moving in the road.
The theme of your moving picture is: ________________________________

Please draw the moving picture you’re planning to design and make:

From where did you get your ideas?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What are the most important reasons (criteria) that make you decide to make this moving picture?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What are your next steps? For example, the moving parts of the picture will have an effect to the appropriate linkage?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Now is time to decide about the appropriate type of linkage for your moving picture. It is important to keep in mind what exactly are the moving parts of your picture. Please experiment with the card models of linkages in order to gain experiences before deciding for the most appropriate (the linkages models are shown in the following pictures). If you like you can also make a card model for linkages of your choice.

- If you require additional information in order to make a decision then search for it.
- If you require further help you can ask your teacher.

**Linkage A**

**Linkage B**

**Linkage C**

**Linkage D**

○ Moving linkage  ● Non moving linkage
The appropriate type of linkage for my moving picture is:  A    B    C    D    Other (if other please make a sketch of your linkage)

What are the most important reasons that make you decide to use this linkage?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Did you use any information that helps you to make your decision?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What are your next steps? How the parts of your picture will be connected?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
The Decoration of the Picture

During this stage you will decorate your moving picture. You can use different materials such as fabric, card, wool etc. You can also use markers or colour pencils to paint your moving picture.

What are the most important reasons that make you decide to use this decoration?
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Did you use any information that helps you to make your decision?
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

If you had the chance to change something in your moving picture what will you change?
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Το υλικό του μπρελόκ

Το υλικό που αποφάσισα να χρησιμοποιήσω είναι:

Περίγραψε τους λόγους για τους οποίους αποφάσισες να χρησιμοποιήσεις το συγκεκριμένο υλικό.

Τι σε βοήθησε να πάρεις την απόφαση αυτή;

Ποια είναι τα επόμενα σου βήματα; Νομίζεις ότι οι αποφάσεις που πήρες μέχρι τώρα μπορούν να επηρεάσουν το σχήμα που θα έχει το μπρελόκ;
### Observation of Decision-Making Strategies

<table>
<thead>
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<tr>
<td>5 min</td>
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</tr>
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<td>10 min</td>
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<td>40 min</td>
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<tr>
<td>45 min</td>
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#### Classroom Activities

<table>
<thead>
<tr>
<th>Types of Criteria (1-8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Engagement (1-3)</td>
</tr>
<tr>
<td>Sources of Information (1-10)</td>
</tr>
</tbody>
</table>

#### Type of Design Decisions

(Complete after concluding the Observation)

<table>
<thead>
<tr>
<th>Not Apparent</th>
<th>Somewhat Apparent</th>
<th>Definitely Apparent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Classroom Activities

<table>
<thead>
<tr>
<th>L</th>
<th>Lecture</th>
<th>SW</th>
<th>Seat Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Lecture w/Discussion</td>
<td>CD</td>
<td>Class Discussion</td>
</tr>
<tr>
<td>TC</td>
<td>Teacher Circulating, Interacting</td>
<td>Ha</td>
<td>Hands on</td>
</tr>
<tr>
<td>D</td>
<td>Teacher is Demonstrating</td>
<td>SG</td>
<td>Small Group</td>
</tr>
</tbody>
</table>

#### Types of Criteria

1. Attractiveness
2. Time limitations
3. Functionality
4. Cost
5. Ergonomic
6. Availability
7. Other (specify)

#### Sources of Information

1. Teacher
2. Subject Book
3. Internet
4. Existing Projects
5. Peers
6. Additional Book
7. Existing knowledge
8. Trial and Error
9. Modeling
10. Other (specify)

#### Student Engagement in Decision-Making Activities

<table>
<thead>
<tr>
<th>1 Low</th>
<th>2 Moderate</th>
<th>3 High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%--49%</td>
<td>50%--74%</td>
<td>75%--100%</td>
</tr>
</tbody>
</table>

#### Decision-Making Strategies Observed

1
2
3
4

#### Difficulties Observed

1
2
3
4
Comments – Additional Notes:

Classroom Activities

CD  Class Discussion:  Students in the context of the whole group do almost all of the speaking. The teacher is a moderator.

D  Teacher is Demonstrating:  The teacher is modeling or demonstrating how to complete a problem or activity.

Ha  Hands-on/Minds On Activity:  Students are participating in an inquiry or other activity that involves manipulating materials.

L  Lecture:  The teacher talks almost the entire time. If students participate verbally, their interactions are brief questions or answers to teacher comments or questions. “Lecture” may include teacher instructions to the class.

LD  Lecture with Discussion:  The teacher talks most of the time. This differs from lecture in that students are asking and/or responding with more than one word questions or responses. There is a clear exchange going on between the students and the teachers. LD differs from Class Discussion in that there is almost no student-to-student discussion.

SG  Small Group:  Structured small group with individual roles, group accountability, and group processing.

SW  Seat Work:  Students are working independently at their desks on a design project.

TC  Teacher Circulating and Interacting:  The teacher circulates about the room, interacting with students.

STUDENT ENGAGEMENT

Code the Average Level of Student Engagement in Decision-Making that occurred during the 5-minute observation period

1  Low Engagement  0-49% of students are engaged
2  Moderate Engagement  50-74% of students are engaged
3  High Engagement  75-100% of students are engaged
Appendix 3.4: Main Study Pre-observational Interview Protocol

What are your expectations from a good teacher?

- Prompt: what are the good characteristics of a teacher?

What kinds of design projects did you work with during your studies in design and technology?

- Prompt: Are the design projects set to you from your design and technology teacher more complex as you go through a different class?

Do you normally take design decisions (materials, shapes, mechanism etc) during your involvement in the project?

- Prompt: Do your teachers give you choices during your design projects? Or do they explain exactly what and how you will go on?
- Prompt: What is the participation of your teacher in the design decisions?

Can you give me an example of decision that you made while working with your design project?

- Prompt: do you know why you made that decision? (If they don’t know why?)

If the decision is not straightforward do you search for further information that might help you make your design decision?

- Prompt: What sources of information do you use (books, teachers, internet, observation etc)?
- Prompt: What about the books that you use in design and technology?
- Prompt: Do your teacher give you additional teaching or information that help you with your design decisions?
- Prompt: Do you think that you use different sources of information as you grow older?

When you have to take a design decision do you think of any factors (criteria) that the decision should satisfy?

- Prompt: are those factors (criteria) equally important?
- Prompt: how do you handle them if you have multiple criteria?

Do you think that the decision making skills that you learned during the design and technology lessons can be used (transferred) to other daily activities?

- Prompt: can you give me any example from your experience?

Tell me a decision about something that you buy recently.

- Prompt: what about your mobile phone? How exactly you decide to buy the specific model?
Appendix 3.5: Main Study Post-observational Interview Protocol

Do you think that during this design project you had to take more design decisions than you normally do?

Can you give me an example of decision that you made while working with your design project?
  - Prompt: How did you make that decision?
  - Prompt: What other choices did you have? Why you choose that?

Did you search for further information that helped you take that decision?
  - Prompt: What sources of information did you use (books, teachers, internet, observation etc)?
  - Prompt: Do you think that you use different sources of information as you go through?

When you took that decision did you think of any factors (criteria) that the decision should satisfy?
  - Prompt: are those factors (criteria) equally important?
  - Prompt: how did you handle those multiple criteria?

Tell me a decision about something that you buy recently.
  - Prompt: what about your mobile phone? How exactly you decide to buy the specific model?

Do you think that the decision making skills you learned during the design and technology lessons can be used (transferred) to other daily activities?
  - Prompt: can you give me any examples from your experience?

If you had the chance to change a decision will you change anything?
  - Prompt: why? How exactly will you do it?

Did you find any difficulties taking that decision?
  - Prompt: what else do you think that might help you take more rational decisions?
Appendix 3.6: Main Study Decision-Making Task

The following table shows the projects that I am thinking to use with students in order to explore their decision making abilities. The projects are based on the Cypriot curriculum.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project - Task</th>
<th>Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Car with any source of energy</td>
<td>1. Source of Energy&lt;br&gt;e.g. solar cell, battery, elastic band&lt;br&gt;2. Construction Materials&lt;br&gt;e.g. plastic, wood, cardboard</td>
</tr>
<tr>
<td></td>
<td><strong>(option 1)</strong></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Little hanger for their room</td>
<td>1. The theme of the hanger hands and move, ears&lt;br&gt;e.g. animal, sports logo, flower&lt;br&gt;2. Construction Materials&lt;br&gt;e.g. plastic, wood</td>
</tr>
<tr>
<td></td>
<td><strong>(option 2)</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Simple Car model with mechanisms</td>
<td>2. Type of Mechanism&lt;br&gt;e.g. gears or pulleys&lt;br&gt;2. Construction Materials&lt;br&gt;e.g. plastic, wood, cardboard</td>
</tr>
<tr>
<td>9</td>
<td>Electronic Alarm System</td>
<td>1. Electronic components for Input, process, output&lt;br&gt;2. The purpose of the Alarm system&lt;br&gt;e.g. automatic light when is dark or. Fire alarm system etc.</td>
</tr>
</tbody>
</table>
Appendix 3.7: Pilot study Pre-test and Post-test

Task 1.1

George is planning to buy a piece of land in order to build his house inside. After searching for a long time he has concluded in two optional locations (place A and place B) and he tries to decide which one is the best choice.

His decision will be based on two criteria:

The price (he wants it to be as cheap as possible)
The time required for traveling to his work (he wants the minimum travel time)

In the following table there is information about the two places:

<table>
<thead>
<tr>
<th></th>
<th>Location A</th>
<th>Location B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£40 000</td>
<td>£60 000</td>
</tr>
<tr>
<td>Time required for traveling to his job</td>
<td>17 minutes</td>
<td>8 minutes</td>
</tr>
</tbody>
</table>

What would you do if you were in George position? Explain your thought.
Task 1.2

The government decided to build a new desalination station in order to satisfy the demands of potable water. There are two possible locations for building the power station: Mari and Zygi.

The government’s decision will be based on the following criteria:

The number of people that will be benefit from the station
The cost of building the station

In the following table there is information about the two locations:

<table>
<thead>
<tr>
<th></th>
<th>Mari</th>
<th>Zygi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people that will be benefit</td>
<td>110 000 people</td>
<td>105 000 people</td>
</tr>
<tr>
<td>Cost of the station</td>
<td>£90 000</td>
<td>£65 000</td>
</tr>
</tbody>
</table>

If you were a government consultant, which place would you recommend for building the desalination station, Mari or Zygi? Explain your thought.
Task 2.1

Mary is planning to buy a piece of land for building her house. After searching for a long time she has limited her options into two alternative locations (location A and location B) and she tries to decide which one is the best choice.

Her decision will be based on three criteria:
The price (she wants it to be as cheap as possible)
The time required for traveling to his work (To spent the minimum time for traveling to her work)
The noise level (she prefers to be in a quiet area)

In the following table there is information about the two locations:

<table>
<thead>
<tr>
<th></th>
<th>Location A</th>
<th>Location B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£40 000</td>
<td>£48 000</td>
</tr>
<tr>
<td>Time require for traveling to her job</td>
<td>25 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Quite/noisy area</td>
<td>Very quite area</td>
<td>The land is on a main road and it is quite noisy during the day</td>
</tr>
</tbody>
</table>

What you would do if you were in Mary’s position? Explain your thought.
Task 2.2

Mary is planning to buy land for build her house. She has searched for a long time and now she is in between two locations (location A and location B) and she tries to decide which one is the best choice.

In order to decide about the best place to buy land she set three criteria:

- The price (she wants it to be as cheap as possible)
- The time required for traveling to his work (To spent the minimum time for traveling to her work)
- The noise level (she prefers to be in a quiet area)

In the following table there is information about the two locations:

<table>
<thead>
<tr>
<th></th>
<th>Place A</th>
<th>Place B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>£40 000</td>
<td>£48 000</td>
</tr>
<tr>
<td>Time require to travel to her job</td>
<td>25 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Quiet/noisy area</td>
<td>The land is on a main road and it is quite noisy during the day</td>
<td>Very quiet area</td>
</tr>
</tbody>
</table>

She decided to ask for help from her friends, Helen and Karen.

Helen: “I think that you should choose location A. Because the most important criterion is the price of the land, location A, which is the cheapest, is the best option. The other two criteria are not that important (quite area and time that is required for traveling to work)”

Karen: “I think that you should choose location B. Even thought it is a little more expensive, you should take into account that is better comparing to location A regarding the other two criteria: it is closer to your job and it is in a quiet area.”

Do you agree with Helen, with Karen or neither of them? Explain your thought.
Task 3 (3 X 3)

The government decided to build a new electric power station in order to satisfy the increasing demands of electric power. There are three possible areas for building the power station: Hirokitia, Zygi and Sotira.

The decision for the location will be based on the following criteria:
The cost of the station
The distance from build-up areas (people who live nearby usually oppose to such constructions)
The distance from the sea (it is important to be near the sea)

In the following table there is information about the three locations:

<table>
<thead>
<tr>
<th></th>
<th>Hirokitia</th>
<th>Zygi</th>
<th>Sotira</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from build-up areas</td>
<td>4 Km</td>
<td>2 Km</td>
<td>5 Km</td>
</tr>
<tr>
<td>Cost of the construction</td>
<td>£200 000</td>
<td>£210 000</td>
<td>£180 000</td>
</tr>
<tr>
<td>Distance from the sea</td>
<td>3Km</td>
<td>1Km</td>
<td>4 Km</td>
</tr>
</tbody>
</table>

For the government the most important criterion is the distance from the sea. The next most important criterion is the building cost and the third is the distance from build-up areas.

If you were a government consultant, which location would you recommend for building the station? Explain your thought.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Task 4

The government decided to build a new electric power station in order to satisfy the increasing demands of electric power. There are three possible locations for building the power station: Pentagomo, Hirokitia and Sotira.

The government assigned Dr. Panayiotou, a scientist specialized in power stations, to analyze the three possible locations and suggest the best one for building the station. Another scientist, Dr. Theodorou was asked from an environmental organization to do the same analysis.

After the analysis of the three areas Dr. Panayiotou argued that the best location for building the power station is Sotira. In contrast, Dr. Theodorou asserted that Hirokitia is the most appropriate area for building the station.

The results of the projects were discussed in the news broadcast on television.

Andreas is a student who watched the news broadcast on television and had the following thought:

“One of the two scientists must have done a mistake. It is impossible to end up with different decisions. They were supposed to choose the same area.”

Do you think that Andreas is right or wrong? Explain your thought.
Appendix 4.1: Main Study Pre-test and Post-test

Pre-test and Post-test Task 1

The government decided to build a new electric power station in order to satisfy the increasing demands of electric power. There are three possible areas available for building the power station: Hirokitia, Zygi and Sotira.

The decision for the location will be based on the following criteria:

- The cost of the station
- The distance from build-up areas (people who live nearby usually oppose to such constructions)
- The distance from the sea (it is important to be as near the sea as possible)

In the following table there is information about the three locations:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Hirokitia</th>
<th>Zygi</th>
<th>Sotira</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from build-up areas</td>
<td>4 Km</td>
<td>2 Km</td>
<td>5 Km</td>
</tr>
<tr>
<td>Cost of the construction</td>
<td>£200 000</td>
<td>£210 000</td>
<td>£180 000</td>
</tr>
<tr>
<td>Distance from the sea</td>
<td>3 Km</td>
<td>1 Km</td>
<td>4 Km</td>
</tr>
</tbody>
</table>

If you were a government consultant, which location would you recommend for building the station? Explain your thought.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Are there any additional information that might help you to take (or improve) the decision? Where will you search to find them?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Explain how you use the criteria listed in the table? You think that all of them are equally important?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Pre-test and Post-test Task 2

Maria is looking for a new mobile phone to buy. After a long search she ended up with three possible phones. The following table contains information about the three phones.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Nokia N81</th>
<th>Samsung G600</th>
<th>Sony Ericsson W910i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>€370</td>
<td>€420</td>
<td>€330</td>
</tr>
<tr>
<td>Weight</td>
<td>140g</td>
<td>105g</td>
<td>86g</td>
</tr>
<tr>
<td>Camera</td>
<td>2 Mega pixels</td>
<td>5 Mega pixels</td>
<td>2 Mega pixels</td>
</tr>
<tr>
<td>Memory</td>
<td>8 GB</td>
<td>2 GB</td>
<td></td>
</tr>
<tr>
<td>3G</td>
<td>Yes</td>
<td>no</td>
<td>Yes</td>
</tr>
<tr>
<td>Talk time</td>
<td>4h</td>
<td>3.5h</td>
<td>9h</td>
</tr>
<tr>
<td>Standby</td>
<td>410h</td>
<td>300h</td>
<td>400h</td>
</tr>
</tbody>
</table>

What would you do if you were in Marias place? Explain your thought.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Are there any additional information that might help you to take (or improve) the decision? Where will you search to find them?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Explain how you use the criteria listed in the table? You think that all of them are equally important?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Appendix 4.2: Main Study Log-book
A. Mettas PhD 2011

Decision Making

Type of the decision:

What are your options? (Write down the possible options that you have)

CONSEQUENCES

VALUES

Consequences
For each option given above explain what will happen if you take this option? And why?

Values
How important is the consequence? Why?

DECISION

1. Which option is best in light of the consequences? What are the most important reasons that make you choose that option?

2. From where did you get your ideas? (sources of information)

3. What are your next steps? How the decision taken will affect your next steps?

Decision Making - Example
**Type of the decision: The type of mechanism**

<table>
<thead>
<tr>
<th>Consequences</th>
<th>Values</th>
</tr>
</thead>
</table>
| **Pulleys:** 1. easy to adjust, because the elastic band can easily be adjusted in almost any distance  
2. not very efficient because of the elastic band will slip from the pulley | 1. Very important because it will take less time to adjust the mechanism compared to the other options  
2. Not very important for this project, it might be little slower but is not that important |
| **Compound Gears:** 1. Difficult to adjust because I will need 4 gears  
2. Very efficient, because the motion will be transferred with accuracy | 1. Very important, I will need a lot of accuracy for that mechanism and more time compared to other options  
2. Not very important for this project, it might be little slower but is not that important |
| **Bevel Gears:** 1. Not very difficult to adjust, not that difficult as compound gears but not that easy as pulleys  
2. Efficient - much more efficient than pulleys and quite competitive with compound gears  
3. Good reduction speed, because of the nature of the gears | 1. Very important, I have to be a little careful to adjust them  
2. Not very important for this project, it might be little slower but is not that important  
3. Important because I will have good power to my car model |

1. Which option is best in light of the consequences? What are the most important reasons that make you choose that option?

I decided to use bevel gears because it's a mechanism that is not very difficult to adjust on my project, is quite efficient and it can give me good reduction speed so my car will have to power to move easily.

The reasons that made me decide that mechanism is that the available time for the project is not that long and therefore I will take risk is I use compound gears. Pulleys is the second best option for my project but it will not be very efficient so I didn't choose it.

2. From where did you get your ideas? (sources of information)

I got my ideas mainly from the information given in my textbook, from discussions with my teacher and classmates. I also looked for some information in internet as well.

3. What are your next steps? How the decision taken will affect your next steps?

My next step is to decide the size of my car. My decision will affect the size of my car model because of the size of the gears and their efficiency.
Annexes

1. Photos of Children’s Designs
2. Statistical Analysis of Observation Data (SPSS file)
3. Examples of coding’s of Teachers Interviews of Pilot Study
4. Examples of coding’s of Children Interviews of Pilot Study
5. Examples of Children’s log-books were analysis of Pilot Study

Fracture & label the data: In vivo coding