Brunei Children's understanding of Science:
The influence of change in language of instruction on conceptual development

Hajah Romaizah Bte Hj Md Salleh

This thesis is presented for the Degree of Doctor of Philosophy of Curtin University of Technology

February 2004
Declaration

This thesis contains no material which has been accepted for the award of any other
degree or diploma in any university.

To the best of my knowledge and belief this thesis contains no material previously
published by any other person except where due acknowledgment has been made.

Signa

Date: 5-2-2004
ABSTRACT

In 1987, as a matter of utmost urgency and importance, Negara Brunei Darussalam called for a new system of education that emphasized nationalistic commitment: "Languages for Bruneians". With the era of globalization, the Brunei Ministry of education argued that new patterns of communication were necessary and implemented a bilingual policy where children are taught in Malay until the fourth year of primary school when the medium of instruction changes to English.

While the new policy supports Bruneians' proficiency in two languages, rumour has been magnified through recent established research findings that a large percentage of pupils are underachieving in science. The main focus of this study is the effect of language transfer, from Malay to English as the medium of instruction, on the development of children's conceptual understanding in science. Two clusters of science concepts, evaporation and condensation and living and non-living, provide the science context through which children's understanding is explored. The theoretical framework that includes viewing and examining children's conceptual understanding from conceptual development and epistemological and ontological perspectives of conceptual change informs the analysis of this study.

The research design employed a cross sectional case study method involving the administration of interviews to a total of 255 children aged between 6 and 12 years of age. The interviews about the concepts of evaporation and condensation involved two phases. For the first phase, 60 children from each primary level of 1, 3 and 4 (total n = 180) were interviewed. Fourteen months later, 18 children from the same sample were selected based on their fluency in the first interviews and revisited for more detailed interviews. For the concepts of living and non-living, 75 children were chosen from a wider range of primary levels, fifteen from each level of Primary 1, 3, 4, 5 and 6.

Each participant in this study was asked 2 types of questions; forced-response and semi-structured. For the forced-response questions, scores were entered into the Statistical Packages for Social Sciences (SPSS) computer software based on a 5-point scale. For the semi-structured questions, analysis involved initial grouping of responses before entry into the software and quantitative manipulation. The data
from the semi-structured interviews also were analysed qualitatively with systematic searches for themes and evidence that supported and disconfirmed the quantitative results. As this study produced qualitative as well as quantitative data, rigour was determined by two sets of parallel criteria. Ensuring rigour for the quantitative data involved the criteria of validity and reliability. Within the qualitative paradigm, the criteria that evolved in response to the quality of the research were credibility, transferability, dependability and confirmability.

The results indicated a steady progress of conceptual understanding when the pupils’ explanations about the concepts of evaporation and condensation were in Malay. However, the pattern of development of understanding did not reach projected patterns in Primary 4 when only English responses were analysed. The findings show that the change in language of instruction significantly hampered communication about and possibly conceptual understanding of the cluster of concepts associated with evaporation and condensation. Similarly, the findings about children’s conceptual understanding of living and non-living suggested that the expected patterns of development were not realised. Closer qualitative inspection of the data revealed that the idiosyncratic nature of the bilingual system perpetuated particular misconceptions specifically related to the nature of the Malay and English languages in both clusters of concepts.

The primary conclusion of the study was that the change in language of instruction from Malay to English in Brunei primary schools had a significant, detrimental impact on the children’s expressed understanding of the concepts associated with evaporation and condensation and living and non-living.
ACKNOWLEDGEMENTS

SYUKUR ALHAMDULILLAH... I am thankful to ALLAH for giving me the strength to complete my research and to write this thesis.

It would have impossible for me to produce this thesis without the guidance and the continuous support and motivation from a number of wonderful people. I would first like to thank those people who have been with me throughout this process and allowed me to take on such a challenging academic commitment. But first of all, I wish to thank the government of His Majesty the Sultan and Yang DiPertuan of Negara Brunei Darussalam for granting me the opportunity to undertake the PhD programme under the Brunei Government’s full in-service training scheme. I am deeply appreciative of this financial support, for without it, the commencement of this research would never have become a reality.

My heartfelt thanks go to Professor David F. Treagust and Dr. Grady Venville, my supervisors and committee chair, whose knowledge, experience and insight into educational theory has helped me to deepen my understanding on many educational grounds. The completion of this thesis is possible only because of their invaluable guidance, continuous professional supervision, stimulating and constructive feedback and generosity with time during the preparation of this thesis. Throughout my three years enrolled in the Science and Mathematics Education Centre, David and Grady have served as advisers and close family to me. To Professor David, thank you very much for accepting me as one of your students. Your ideas, your knowledge and your expertise in conceptual change are well-known to all science researchers. I am much honored to be given such an opportunity to learn from you and to share my ideas. To Dr. Grady, your expertise in children’s understanding on living is very much reflected in the interrogation of the data in this study. I appreciate your willingness to explore the data with me and your patience and tolerance in checking my English grammar and in clarifying my sentences.

My very special thanks go to the teachers and the 255 wonderful children who participated in my study. Without their cooperation and responses, this study would never have happened.
I must acknowledge and thank several members of my family for their quiet prayers and love that made it possible for me to complete this thesis. For my husband, Mohd Fadzil, thank you very much for your constant support, encouragement and forbearance. For the past three years, you have given me the time and space that I really needed. To my daughters, Fatin Nabeela and Fatin Naqubah, thank you very much for being so understanding, considerate and loving, even though mummy didn’t help you a lot with your homework! And lastly, to my son, Muhammad Haziq Najwan, thank you for being a sweet little boy. Without my family’s loving involvement, the writing of this thesis would have been next to impossible.

To the only man who has always been a great influence in my life, my beloved father, Allahyarham Hj Md Salleh Hj Mukibat, who passed away on 23rd July 2000. You have implanted in me your strong principle of life-long learning. You are my inspiration. You may have gone, but you’ll never be forgotten! Al Fatihah... To my beloved mother, Hjh Tiapnah Hj Metusin, thank you very much for your support and encouragement and for generously offering assistance in the care of my children. And last, to my beloved sisters, Khairiah, Noor Maya, Khairunnida and Noor Izwah, thank you for looking after my daughters’ educational matters. If I can do this, so can you!

My thanks also extended to Professor Barry Fraser for being supportive and for giving me the opportunity to study at the Science and Mathematics Education Centre. To my colleagues at SMEC, thank you very much for your assistance and friendship. In particular, I wish to thank Dr. Chi-Yan Tsui. This gentleman introduced me to the End-note software system and supported my computing efforts with many other tips and pointers. Thanks for your time and your help. For their help and inspiration, I wish to thank my mates, travelling companions, close friends and colleagues, Hjh Jamilah and Hjh Rohani for the quality time spent with me. We have shared every dream, every anxiety, every enjoyment and every tear together. I’ll definitely miss those occasions. “Hey...put your foot on it, pump it harder, I’m very hungry”, “I cook the rice, you fry the chicken!”, “Ok, make it two pots of rice!!!!”

After three hard years, at last I DID IT!!!!
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapters</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>ii</td>
<td></td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
<td></td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
<td></td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vii</td>
<td></td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xii</td>
<td></td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xv</td>
<td></td>
</tr>
<tr>
<td>CHAPTER 1</td>
<td>BACKGROUND, RATIONALE AND PURPOSE</td>
<td>1</td>
</tr>
<tr>
<td>1.0</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>Rationale of the Study</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>Purpose</td>
<td>2</td>
</tr>
<tr>
<td>1.3</td>
<td>Research Questions</td>
<td>4</td>
</tr>
<tr>
<td>1.4</td>
<td>Hypothesis</td>
<td>5</td>
</tr>
<tr>
<td>1.5</td>
<td>Significance of the Study</td>
<td>6</td>
</tr>
<tr>
<td>1.6</td>
<td>Structure of the Study</td>
<td>9</td>
</tr>
<tr>
<td>CHAPTER 2</td>
<td>LITERATURE REVIEW: BILINGUAL EDUCATION AND SCIENCE</td>
<td>11</td>
</tr>
<tr>
<td>2.0</td>
<td>Introduction</td>
<td>11</td>
</tr>
<tr>
<td>2.1</td>
<td>Background and Context of the Study</td>
<td>11</td>
</tr>
<tr>
<td>2.2</td>
<td>Issues of Language Use in Societies</td>
<td>13</td>
</tr>
<tr>
<td>2.3</td>
<td>Bilingualism and Bilingual Education – Definitions</td>
<td>13</td>
</tr>
<tr>
<td>2.4</td>
<td>Rationales for Bilingual Education</td>
<td>14</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Ideological reasons for bilingual education</td>
<td>14</td>
</tr>
<tr>
<td>2.4.2</td>
<td>International reasons for bilingual education</td>
<td>15</td>
</tr>
<tr>
<td>2.4.3</td>
<td>Individual reasons for bilingual education</td>
<td>16</td>
</tr>
<tr>
<td>2.5</td>
<td>The Significance of English Language in Brunei Education</td>
<td>17</td>
</tr>
<tr>
<td>2.6</td>
<td>Political Issues in Brunei that Influenced Language use in Education</td>
<td>17</td>
</tr>
<tr>
<td>2.7</td>
<td>Bilingual Education in Brunei</td>
<td>19</td>
</tr>
<tr>
<td>2.8</td>
<td>Brunei Bilingual System and Problems</td>
<td>20</td>
</tr>
<tr>
<td>2.9</td>
<td>Other Countries and Bilingual Education</td>
<td>23</td>
</tr>
<tr>
<td>2.9.1</td>
<td>Singapore</td>
<td>23</td>
</tr>
<tr>
<td>2.9.2</td>
<td>Philippines</td>
<td>24</td>
</tr>
<tr>
<td>2.9.3</td>
<td>Malaysia</td>
<td>25</td>
</tr>
<tr>
<td>2.9.4</td>
<td>Inference</td>
<td>25</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2.10</td>
<td>Bilingualism and the Age Factor</td>
<td>27</td>
</tr>
<tr>
<td>2.11</td>
<td>Bilingualism and Cognitive Development</td>
<td>28</td>
</tr>
<tr>
<td>2.12</td>
<td>Gender and Second Language Acquisition</td>
<td>30</td>
</tr>
<tr>
<td>2.13</td>
<td>English Language and Science Learning</td>
<td>33</td>
</tr>
<tr>
<td>2.14</td>
<td>Summary</td>
<td>37</td>
</tr>
<tr>
<td>3.0</td>
<td>Introduction</td>
<td>39</td>
</tr>
<tr>
<td>3.1</td>
<td>Learning Science in Brunei</td>
<td>39</td>
</tr>
<tr>
<td>3.2</td>
<td>Concepts Taught in Brunei Primary Science</td>
<td>42</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Children's conceptions of evaporation and condensation</td>
<td>42</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Children's conceptions of living and non-living</td>
<td>47</td>
</tr>
<tr>
<td>3.3</td>
<td>The Importance of Language for Conceptual Understanding</td>
<td>51</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Conceptual development and language</td>
<td>53</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Conceptual development and second language</td>
<td>54</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Vygotsky's framework - Language and constructivism</td>
<td>55</td>
</tr>
<tr>
<td>3.3.4</td>
<td>Instructional interaction</td>
<td>57</td>
</tr>
<tr>
<td>3.4</td>
<td>A Theoretical Background</td>
<td>59</td>
</tr>
<tr>
<td>3.4.1</td>
<td>Learning as conceptual change</td>
<td>59</td>
</tr>
<tr>
<td>3.4.2</td>
<td>Perspectives of conceptual change</td>
<td>61</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Using conceptual change theory in this study</td>
<td>65</td>
</tr>
<tr>
<td>3.5</td>
<td>Theoretical Framework</td>
<td>66</td>
</tr>
<tr>
<td>3.6</td>
<td>Summary</td>
<td>69</td>
</tr>
<tr>
<td>4.0</td>
<td>Introduction</td>
<td>71</td>
</tr>
<tr>
<td>4.1</td>
<td>Research Questions and Methodology</td>
<td>71</td>
</tr>
<tr>
<td>4.2</td>
<td>Research Approach</td>
<td>71</td>
</tr>
<tr>
<td>4.3</td>
<td>Two Cross Sectional Case Studies as the Research Design</td>
<td>74</td>
</tr>
<tr>
<td>4.4</td>
<td>Qualitative Data Collection Methods</td>
<td>76</td>
</tr>
<tr>
<td>4.5</td>
<td>Data Sources</td>
<td>77</td>
</tr>
<tr>
<td>4.5.1</td>
<td>Context of the participants</td>
<td>77</td>
</tr>
<tr>
<td>4.5.2</td>
<td>Participants</td>
<td>77</td>
</tr>
<tr>
<td>4.6</td>
<td>Data Collection Techniques</td>
<td>80</td>
</tr>
<tr>
<td>4.6.1</td>
<td>Interview</td>
<td>80</td>
</tr>
<tr>
<td>4.6.2</td>
<td>Limitations of interviews</td>
<td>81</td>
</tr>
<tr>
<td>4.6.3</td>
<td>Interview protocols</td>
<td>82</td>
</tr>
<tr>
<td>4.6.4</td>
<td>Classroom observation</td>
<td>91</td>
</tr>
<tr>
<td>4.7</td>
<td>Data Collection Procedures</td>
<td>97</td>
</tr>
</tbody>
</table>
CHAPTER 7 CHILDREN’S UNDERSTANDING OF EVAPORATION AND
CONDENSATION: AN ANALYSIS FROM ONTOLOGICAL AND
EPISTEMOLOGICAL PERSPECTIVES OF CONCEPTUAL
CHANGE........................................................................... 174

7.0 Introduction.............................................................................. 174

7.1 Research Question 1d: What are the ontological differences about the concepts
of evaporation and condensation across the primary levels 1 – 4?..................... 175
7.1.1 Findings............................................................................ 176
7.1.2 Conclusions......................................................................... 186

7.2 Research Question 1e: What is the status of the children’s conceptions of
evaporation and condensation from Primary 1 – 4?........................................ 188
7.2.1 Findings............................................................................ 188
7.2.2 Conclusions......................................................................... 209

7.3 General Conclusions and Discussions.................................................. 212

CHAPTER 8 CHILDREN’S UNDERSTANDING OF LIVING AND NON-LIVING
THINGS: AN ANALYSIS FROM DEVELOPMENTAL AND
ONTOLOGICAL PERSPECTIVES.................................................. 213

8.0 Introduction.............................................................................. 213

8.1 Research Question 2a: What are Brunei children’s naive conceptions about
living and non-living things?..................................................................... 214
8.1.1 Findings............................................................................ 214
8.1.2 Conclusions......................................................................... 227

8.2 Research Question 2b: Is there any indication of a pattern of development of
understanding of the concept of living and non-living things from Primary 1 –
6? What impact does language transition have on this pattern of development?.... 228
8.2.1 Findings............................................................................ 228
8.2.2 Conclusions......................................................................... 238

8.3 Research Question 2c: Do boys’ and girls’ conceptions of living things progress
in the same way?.............................................................................. 239
8.3.1 Findings............................................................................ 239
8.3.2 Conclusions

8.4 Research Question 2d: What are the ontological differences in the way that children understand the concepts of living and non-living things across the primary levels 1 – 6?

8.4.1 Findings

8.4.2 Conclusions

8.5 General Conclusions and Discussions

CHAPTER 9 CONCLUSIONS AND IMPLICATIONS

9.0 Introduction

9.1 Overview of Important Aspects of Previous Chapters

9.2 General Conclusions

9.3 Limitations to the Study

9.4 Implications

9.5 Recommendations

9.6 Future Research

9.7 Finale

REFERENCES

APPENDICES

Appendix A The complete interview protocol for evaporation and condensation for the lower primary level (translated into English)

Appendix B The complete interview protocol for evaporation and condensation for the upper primary level

Appendix C The complete interview protocol for evaporation and condensation for the lower primary level

Appendix D The science syllabus for elementary school in Negara Brunei Darussalam

Appendix E The complete interview protocol for living and non-living for the upper primary level

Appendix F The complete interview protocol for living and non-living for the lower primary level
LIST OF TABLES

Table 3.1  Summary of aspects of theoretical framework used to address each of the research questions 70
Table 4.1  Research methodology matrix 72
Table 4.2  An outline of the research approach 74
Table 4.3  Profiles of 18 children interviewed in the second phase of Case Study 1 78
Table 4.4  Distribution of pupils' participation in Case Study 1 and Case Study 2 79
Table 4.5  Sample size by gender 79
Table 4.6  The shared- forced-response interview questions on water, evaporation and condensation 85
Table 4.7  Similar questions for lower and upper primary in the semi-structured interview questions 86
Table 4.8  The forced-response interview questions for the concepts of living and non-living 88
Table 4.9  The semi-structured interview questions on the concepts of living and non-living 90
Table 4.10 The summary of classroom visits 92
Table 4.11 Frequency of Malay sentences used in four upper primary classes 94
Table 4.12 Coding generated for responses to the evaporation and condensation semi-structured interview questions 103
Table 6.1  Number of children giving various explanations of the first scenario: One hour after rain, what would happen to the puddle of water? Why? 134
Table 6.2  Number of participants giving various explanations of the second scenario: What is happening to the wet clothes as they are hung under the sun? Why? 135
Table 6.3  Number of participants giving various explanations for the third scenario: Water in a dish left under the sun disappears. Why does this happen? 136
Table 6.4  Number of participants giving various explanations of the picture of a water cycle 137
Table 6.5  Response patterns for explanations of the picture of a water cycle 139
Table 6.6  Total numbers of Primary 1 and Primary 4 children giving each kind of response on the three scenarios: water in the puddles, wet clothes and water in a dish 140
Table 6.7  Descriptive statistical data by primary level on evaporation and condensation semi-structured interview with Malay and English responses 145
Table 6.8  Descriptive statistical data by primary level on evaporation and condensation semi-structured interview with English responses in xii
Table 6.9  Descriptive statistical data of children by primary level on water, evaporation and condensation items in the forced-response section of the interview  
Table 6.10  Analysis of variance for water, evaporation and condensation items on the forced-response section of the interview  
Table 6.11  Multiple comparisons for water, evaporation and condensation across primary levels  
Table 6.12  Statistics used to test for differences in means between primary levels for every item about water in the forced-response section of the interview  
Table 6.13  The ANOVA results for children’s performances on items about water in the forced-response section of the interview  
Table 6.14  Multiple comparisons for items about water in the forced-response section of the interview  
Table 6.15  Descriptive statistical data for children’s responses on the concepts of evaporation and condensation  
Table 6.16  ANOVA results for boys’ and girls’ performance on evaporation and condensation  
Table 7.1  The distributions of children’s verbal responses on the puddles of water scenario  
Table 7.2  The distributions of children’s verbal responses on the wet clothes scenario  
Table 7.3  The distributions of children’s verbal responses on the water in a dish scenario  
Table 7.4  The distributions of children’s verbal responses on the picture of the water cycle  
Table 7.5  The distributions of children’s verbal responses based on the categories on the four evaporation and condensation scenarios  
Table 7.6  Total number of children presenting the respective types of responses on the four scenarios combined  
Table 7.7  The status of children’s conceptions of evaporation and condensation  
Table 8.1  Things children gave as examples of living things in the semi-structured interview questions  
Table 8.2  Responses to the question, “Was a dead cat ever living?” in the semi-structured interview questions  
Table 8.3  The scientific criteria that children used when asked to describe what living means in the semi-structured interview questions  
Table 8.4  Children’s responses to the question, “Do you think a plant is living or not living?” in the categorization task
Table 8.5  Children's responses to the question, "Do you think these (plants and animals) are living or not-living?" in the semi-structured interview 223
Table 8.6  Children's responses to the question, "In what ways are these (plants and animals) different?" in the semi-structured interview 223
Table 8.7  Children's responses to the forced-response item, 'A human is an animal' 227
Table 8.8  Descriptive statistical data of children's total scores on their use of scientifically acceptable criteria for living in the semi-structured interview 229
Table 8.9  Descriptive statistical data of children's correct answers on the categorization task 230
Table 8.10  Numbers of children who identified the instances as living in the categorization task 232
Table 8.11  Descriptive statistical data by primary level on the living and non-living forced-response interview 236
Table 8.12  Analysis of variance on the living and non-living forced-response interview using one-way ANOVA 236
Table 8.13  Multiple comparisons for significance across primary levels on the living and non-living forced response interview using Scheffe's test 237
Table 8.14  Descriptive statistical data of study sample by gender on their understanding of the concept of living 240
Table 8.15  ANOVA results for boys' and girls' concepts of living and non-living 241
Table 8.16  Children's responses to the question: "In what ways are these things (pictures of animals and plants) similar?" 244
Table 8.17  Children's responses to the question: "In what ways are these things (pictures of animals and plants) different?" 245
Table 8.18  Number of children who restricted predicates of living things to just animals when asked the differences between plants and animals 249
Table 8.19  Number of children who agreed that the predicates used for animals also can be used for plants 250
LIST OF FIGURES

Figure 1.1  A diagram that illustrates the hypothesis of this study 6
Figure 3.1  A cartoon illustrates a probable occurrence in Brunei classrooms 59
            (Borneo Bulletin, September 10, 2001)
Figure 3.2  The conditions that have to be met for conceptual change to occur 67
            (adapted from Hewson and Hewson, 1992)
Figure 3.3  The theoretical framework that guides this study 68
Figure 4.1  Summary of the interview response types 83
Figure 4.2  A lesson précis 96
Figure 4.3  Summary of data collection schedule 98
Figure 4.4  Three ontologically distinct categories of children’s verbal responses 105
            about evaporation and condensation
Figure 4.5  An idealized ontology of children’s knowledge on the concepts of 106
            evaporation and condensation (adapted from Chi, 1992)
Figure 4.6  Evidence used to classify the status of conceptions as intelligible, 108
            plausible and fruitful
Figure 4.7  Carey’s (1985) categories of ontologically basic concepts 110
Figure 5.1  Mean scores of children on the semi-structured interview questions 123
            with both Malay and English responses in the Pilot Study 1
Figure 5.2  Mean scores of children on the semi-structured interview questions 123
            with only English responses in Primary 4 in Pilot Study 1
Figure 5.3  Mean of children’s total scores on the forced-response interview 125
            questions in Pilot Study 1
Figure 5.4  Children’s mean scores from the semi-structured interview questions 128
            about the characteristics of living with only English responses from
            Primary 4 onwards in Pilot Study 2
Figure 5.5  Children’s mean scores on forced-response interview questions about 130
            living and non-living
Figure 6.1  Mean scores of children in the semi-structured interviews with both 144
            Malay and English responses in Primary 4
Figure 6.2  Mean scores of children in the semi-structured interview with only 144
            English responses in Primary 4
Figure 6.3  Mean scores of children for all evaporation and condensation scenarios 146
            in the semi-structured interview with both Malay and English
            responses in Primary 4
Figure 6.4  Mean scores of children for all evaporation and condensation scenarios 146
            in the semi-structured interview with English responses in Primary 4
Figure 6.5  Children’s responses on the forced-response items about water, 158
            evaporation and condensation

xv
Figure 6.6 Mean of children’s total scores on the forced-response items about evaporation and condensation 160
Figure 6.7 Boys’ and girls’ responses on semi-structured interviews when only English responses were accepted in Primary 4 169
Figure 6.8 Boys’ and girls’ responses on semi-structured interviews when Malay and English responses were accepted 169
Figure 6.9 Boys’ and girls’ responses on forced-response interviews 170
Figure 6.10 Boys’ and girls’ responses on semi-structured and forced-response interview questions 171
Figure 7.1 The breakdown of children’s verbal responses 175
Figure 7.2 Bar chart presenting the number of children who gave each type of response 184
Figure 7.3 Bar chart presenting the number of children in each of Chi’s categories 184
Figure 8.1 Children’s total scores awarded for the use of scientifically acceptable criteria for living in the semi-structured interview with English responses in Primary 4, 5 and 6 229
Figure 8.2 Children’s correct scores on the categorization task 231
Figure 8.3 The number of children who identified the instances as living in the categorization task 233
Figure 8.4 Children’s means scores on the forced-response interview about living and non-living things 238
Figure 8.5 Boys’ and girls’ mean scores for their description of living in the semi-structured interviews 241
Figure 8.6 Boys’ and girls’ mean scores for the categorization task about living and non-living 242
Figure 8.7 Boys’ and girls’ mean scores for the forced-response interview about living and non-living 242
Figure 8.8 Pie charts showing the distribution of children’s responses for Primary 1, 3, 4, 5 and 6 to the question: ‘Do you think these (pictures of animals and plants) are living or not-living?’ 246
Figure 8.9 A generic representation of the children’s ontological conceptions of the concepts of living and non-living things 252
CHAPTER ONE

BACKGROUND, RATIONALE AND PURPOSE

1.0 Introduction

Every child who attends school is immersed in a unique cultural and social educational midlife that impacts on his or her learning of science. Influenced by social, political and economic circumstances, Negara Brunei Darussalam (henceforth called Brunei) has adopted a bilingual system of education that incorporates two languages in imparting its curriculum. For the first three years of school, Brunei children are taught in Malay and then for the remainder of their education, instruction is in English. This thesis is concerned with the influence that this bilingual education system has on children’s learning of science. More specifically, this thesis examines children’s developing understanding of two clusters of concepts within this bilingual system of education in Brunei – evaporation and condensation and living and not living things. The study focuses on children’s transition from Primary 3 to Primary 4, when the change in language of instruction takes place. This first chapter introduces the thesis by outlining the broad contextual background, rationale, purpose, significance and finally the structure of the thesis and an overview of the study. The focus of the chapter is on the presentation of the research questions that guided this study.

1.1 Rationale of the Study

In 1985, Brunei Darussalam adopted a new school curriculum that incorporates two languages. Learning is initially in Bahasa Melayu or the Malay language and from Primary 4, the majority of school subjects are taught in English. The shift from Malay to English is abrupt rather than gradual. From Primary 1 to Primary 3, science, geography and history are taught as a single subject ‘Pelajaran Am’ (General Studies) for only 3 hours per week. Mathematics is taught as an independent subject for about 5 hours a week and, as with all other subjects at this level, it is taught in Malay. From Primary 4 onwards, science, geography and history
are introduced separately with each subject being taught for 3 hours per week. What makes the shift to Primary 4 abrupt and an enormous hurdle for the children is the fact that, in addition to English language as a subject, demanding subjects such as science, mathematics and geography are introduced for the first time in English. This is a difficult transition considering the children have only limited proficiency in English when they complete Primary 3. Not only is the number of English-medium hours considerably increased in Primary 4, the burden of learning increasingly cognitively demanding subjects at the same time compounds the problem.

In recent years, there has been heightened national concern over children’s achievement in science in Brunei. Regardless of this concern, little attention has focused on the role of language proficiency and any association between poor language proficiency and underachievement. The potential success of the bilingual system rests on the assumption that Primary 4 pupils have sufficient proficiency to start learning other discipline-based subjects in English. But what if this assumption is wrong? Pupils will lag behind the required level of language proficiency and the majority will never reach the language standard so crucial for both interaction and learning in the classroom.

1.2 Purpose

There are no easy answers in bilingual education. While the dilemma and practical implications of bilingualism in Brunei per se remains unsolved, the effects of bilingualism on how children develop within the school curriculum have provoked some apprehension from educators. Science has been recognized as an important subject for the children in Brunei because of its implications for higher education, its links with career opportunities and the science-related needs of the country. There is, however, no formal information about the direct effects that bilingualism has on pupils’ learning of science. This study directly addresses this lack of empirical research by examining changes in children’s conceptions in science, in particular, by virtue of introducing a second language as the medium of instruction. It has been documented that with good exposure to social interaction and daily activities, children will pass along predictable patterns of conceptual development about science-related concepts (Vygotsky, 1986). The purpose of this study, therefore, is
to document the patterns of Brunei pupils’ developing understanding of science concepts as a result of the intervention of the second language as the medium of instruction and to juxtapose these patterns with expected trends ascertained from the research literature.

In order to fulfil the purpose of ascertaining pupils’ developing understanding of science concepts, it was necessary to address issues of epistemology. It was necessary to construct a theoretical context that would provide the basis upon which judgments could be made about what it means to understand and what developing understanding in science is and how it can be measured.

The theoretical framework of this study is encapsulated within the theory of knowledge called constructivism. Most cognitive scientists now work within a constructivist model of knowledge which has been summarised in a single statement by Bodner (1986, p. 873) as “knowledge is constructed in the mind of the learner”. Constructivism is a theory of knowledge that contrasts with traditional epistemological theories that knowledge has to be a representation of reality. In contrast, constructivists believe that the only world we can know is the world of our own experience (von Glasersfeld, 1993). This theory contests the belief that knowledge can be transferred to a passive receiver. Rather, knowledge is the result of an active construction process, “it has to be actively built up by each individual knower” (von Glasersfeld, 1993, p. 26). Bodner emphasises that from a constructivist view the most vital factor influencing learning is that knowledge is constructed on the basis of students’ pre-existing cognitive structure. Students’ pre-existing knowledge is, therefore, an essential aspect of learning and development and the research questions developed for this thesis explicitly address the issue of students’ pre-existing knowledge, or naïve conceptions, about the concepts under consideration.

In describing constructivism as a theory of knowledge, Tobin (1993, p. 30) states that “knowledge is constructed and adapted as a result of successive experiences and reflections”. It is this process of construction and adaptation that can be seen as conceptual change. Recent conceptual change theories have become closely aligned with social constructivism, an aspect of the more general theory that emphasises the importance of social exchanges, context dependent experiences, language and
culture (Venville, 2004). The research questions developed for this study drew on the broad umbrella of social constructivism to investigate the impact of language transition and the associated social and cultural context created in a bilingual environment as a lens through which to view the science understanding of Brunei pupils.

What exactly conceptual change is and how it can be identified are still topics keenly debated by educational researchers. Several theories of conceptual change have emerged over recent years, but there have been a significant number of successful studies that have emphasised the use of more than one perspective of conceptual change for empirical research (Harrison & Treagust, 2001; Tyson, Harrison, Venville & Treagust, 1997; Venville, 2004; Venville & Treagust, 1998). In this study, epistemological and ontological perspectives of conceptual change were used to provide direction for the research questions so that appropriate data could be gathered to provide evidence of Brunei pupils’ developing understandings of science.

1.3 Research Questions

The focus of this study was Brunei children’s conceptual development about two clusters of concepts in science. The first cluster included the concepts of evaporation and condensation and other related concepts such as the water cycle and the second included the concepts of living things and non-living things and other related ideas such as death. Nine research questions were developed to guide the methodology for this study, five about evaporation and condensation and four about living and non-living things.

Q 1. Research questions about evaporation and condensation:

a. What are Brunei children’s naïve conceptions about evaporation and condensation?

b. Is there any indication of a pattern of development of understanding of the concepts of evaporation and condensation from Primary 1 – 4? What impact does language transition have on this pattern of development?

c. Do boys’ and girls’ conceptions of evaporation and condensation progress in
the same way?

d. What are the ontological differences about the concepts of evaporation and condensation across the primary levels 1 – 4?

e. What are the epistemological differences about the concepts of evaporation and condensation across the primary levels 1 – 4?

RQ 2. Research questions about living and non-living:

a. What are Brunei children’s naïve conceptions about living and non-living things?

b. Is there any indication of a pattern of development of understanding of the concepts of living and non-living things from Primary 1 – 6? What impact does language transition have on this pattern of development?

c. Do boys’ and girls’ conceptions of living and non-living things progress in the same way?

d. What are the ontological differences in the way that children understand the concepts of living and non-living things across the primary levels 1 – 6?

1.4 Hypothesis

Figure 1.1 illustrates an hypothetically ideal pathway for children’s conceptual development in science. The figure also illustrates a possible pathway as a result of the change in language of instruction in Primary 4. The figure allows us to contemplate the impact that the bilingual system may have on pupils’ science learning and, therefore, presents in diagrammatic form an hypothesis that the change in language of instruction will have a negative effect of pupils’ learning in science.

To the majority of Brunei children, English language is not an everyday language. Most Brunei children have limited opportunity for hearing and speaking English. It is reasonable to anticipate, therefore, that the sudden imposition of the English language will indirectly affect the children’s way of understanding science concepts. Figure 1.1 offers prospect for both ideal and possible pathways through the process of English language introduction during the course of children’s elementary years. If the possible pathway is taken by a high proportion of pupils, the result will
undoubtedly be a certain degree of damage to the children’s understanding of science. Moreover, this potential pathway of learning offers a possible explanation for the undesirable performance of Brunei children in science in more recent years.

![Diagram]

*Figure 1.1* A diagram that illustrates the hypothesis of this study.

**1.5 Significance of the Study**

Because the bilingual system was designed to enhance education in Brunei, it has attracted an increasing degree of attention from researchers (for example, James, 1996; Jones, 2000a, 2000b, 2000c; Martin, 1999). Much of this research took place during implementation of the bilingual system. Jones (2000c) stated that despite the Bruneians’ positive attitudes towards bilingual education, many children were found struggling with both school languages as well as with their subjects. Jones (2000b) also commented that while some students in Form 5 (16 – 17 years old) can communicate in English, most of these students fail the General Certificate of Education ‘O’ level English and thus they leave school without any formal English qualifications. Though Jones (2000b) felt that the examination body is not necessarily an adequate measure of achievement, expectations have to be measured in some way. Martin (1999) observed that the Malay language was used at schools by teachers in order to mediate meanings which most Brunei children did not
understand. In a closely associated finding, Jones (2000c) claimed that one result of introducing the bilingual system with little planning was that teachers were left untrained. Consequently, teachers were not comfortable teaching in the target language. These studies did not explicitly speak of the failure of the bilingual system, however, none of them lauded its success.

This study proceeds beyond the research conducted by these previous studies in several respects. Most importantly, this study was the first to focus on the influence of the change of language on children's developmental understanding of science concepts. This study discloses the potential constraints and dilemmas faced by Brunei primary children in learning science within the bilingual system. As a result of informing relevant authorities of the study outcomes, it is hoped that the results might be used to strengthen the bilingual system to one that is more appropriate for Brunei. Thus, one significant aspect of this study concerns its potential impact on Brunei children's conceptual understanding and pathways of learning in science. The results of this study provide evidence for alternative conceptions and misconceptions that were singled out and tracked to their sources. The recommendations proposed allow teachers to consider how to react when their students bring their cultural and pseudo scientific beliefs to school.

One of the most significant outcomes is that this study will provide evidence for teachers so that they have an opportunity to reflect on their science teaching strategies as well as the way they interact in each language. In this regard, this study provides a potentially strong local impact on collaborating teachers and their colleagues. Suggestions and recommendations will be shared with the local teachers and curriculum developers concerned. The results of the study will hence provide an avenue for discussion among these parties whose pedagogical and curricular decisions have not previously been informed by local empirical evidence. For policy makers and those responsible for curriculum initiatives, an understanding of the children's naïve conceptions provided by this study can guide the introduction and timing of the science topics of evaporation and condensation and living things, particularly in relation to the change in language of instruction and may have an impact on their understanding of how to introduce other science topics.
Another significant aspect of this study is the research theory impact particularly on conceptual change theory. This study provided the opportunity for the researcher to explore and examine the mechanisms underlying theories of conceptual change within the Brunei context. Learning as conceptual change was seen from two perspectives - epistemology and ontology. The study drew on multiple sources of analysis of what might count as evidence of conceptual change so that the researcher could come to robust and reliable conclusions based on evidence generated through these multiple sources. The analysis of the epistemological and ontological perspectives of conceptual change utilised in this study provides vital information for future researchers in determining evidence for conceptual understanding.

Not only is this study likely to impact on research theory, new methodologies were developed and validated. This study pioneered the use of a combination of forced-response items and semi-structured items that can be used in interviews with young children in order to probe their understanding of science concepts. This combination of questions enabled deep probing of understanding while providing systematic data for analysis. New sets of interview protocols were developed for both clusters of science concepts based on previous research. The interview protocols were unique, however, as they were specifically devised for the Brunei context and were written in Malay for the lower primary levels, and in English for the upper primary levels to reflect the language of instruction.

A further significant aspect of this study is the administrative impact. The study has significance for policy makers, for example, that they should consider other factors, such as science learning, that add to the complexity of the issues associated with bilingual education. It is expected that the results of this study will inform relevant authorities about some difficulties associated with the bilingual system and to consider mechanisms that may address these difficulties. For example, it may be possible to realign teacher education programs in Brunei to better prepare teachers for teaching science in two languages. The study has brought to light the possible constraints to be faced by the Brunei Ministry of Education, in particular, in the long-term implementation of the bilingual system. It is anticipated that through the results and recommendations proposed, the relevant authorities will realize that there
are a number of important practical considerations which can impede the success of the bilingual system of education.

1.6 Structure of the Study

The development and findings of this study are presented in nine chapters. This first chapter is the introduction, the next two chapters form the literature review and the fourth and fifth chapters develop the methodology and the pilot study. Chapters 6, 7 and 8 present the findings which are finally drawn together in the concluding chapter, Chapter 9. A brief summary of the content of each of the subsequent chapters follows.

Chapter 2 is the first part of the literature and details a discussion of major writings and previous research on language. The first part of Chapter 2 discusses, in detail, the context by introducing Brunei, the country where this study was conducted and focuses on the bilingual system of education and how it came into being. In the next part of the chapter, issues pertaining to bilingualism and bilingual education in other countries are deliberated. Existing literature detailing the possible advantages of bilingualism are discussed, both in the context of English being the 'other' language and in the context of any language being used to explain scientific phenomena.

The importance of this study is made transparent in Chapter 3, in the second half of the literature review, by considering the status of science learning in Brunei. This chapter presents a review of studies that have examined children's conceptions of evaporation and condensation and also living and non-living things. This chapter also presents an exploration of the theory of conceptual change from epistemological, social/affective, ontological and multidimensional perspectives. This exploration leads to the construction and presentation of a complex theoretical framework used as the basis of interpreting and analyzing data.

Chapter 4 outlines the research methodology with particular reference to the multiple, cross sectional case study and quantitative and qualitative approaches to data collection. The development of interview protocols for each cluster of concepts is described in two different sections in Chapter 4. This chapter also describes the data sources, data collection techniques and the methods used to interpret and
analyse data. Finally, the research rigour and the ethical issues incorporated into this study are outlined.

The pilot study undertaken as a preliminary exercise to the main study is presented in Chapter 5. This chapter focuses on the validity and reliability of the forced-response interview protocols and credibility, transferability, dependability and confirmability of the semi-structured interview protocols of the study.

Chapter 6 reports on and discusses results relevant to Research Question 1a, 1b and 1c, that is, data relating to children’s understanding of evaporation and condensation. The main focus is Brunei children’s conceptual development about the concepts, and whether or not this development follows general patterns and trends reported in earlier research.

The results and analysis of Research Questions 1d and 1e are presented in Chapter 7. This chapter analyses, in detail, evidence for conceptual change in children’s conceptions about evaporation and condensation from two perspectives, epistemology and ontology. ‘Thick descriptions’ of the children’s responses about scenarios on evaporation and condensation are included.

Data relating to children’s understanding of living and non-living things are discussed in Chapter 8. This chapter reports on and discusses results relevant to Research Question 2a, 2b, 2c and 2d. The main focus is whether or not Brunei children’s conceptual development about the concepts of living and non-living things follows the general patterns and trends reported in earlier research. This chapter also analyses children’s conceptual change with regard to their understanding of living and non-living things. Specifically, this chapter focuses on ontological conceptual change.

The researcher’s journey in determining the influence of the change in language of instruction for Brunei children in learning science concepts is concluded in Chapter 9. This final chapter draws conclusion and suggests implications for future research.

Having described the introduction and the structure of this study the next chapter, Chapter 2, focuses on the first half of the literature review.
CHAPTER TWO

LITERATURE REVIEW:
BILINGUAL EDUCATION AND SCIENCE LEARNING

2.0 Introduction

The two main themes that informed and guided the literature review of this study are language and the theory of conceptual change. The focus of this chapter is a review of the literature on language as well as a complex web of related issues such as bilingual education. The focus of the next chapter is a review of the literature on the theory of conceptual change.

The review begins with a brief summary of relevant cultural, educational and contextual information about Negara Brunei Darussalam. The issues associated with bilingual education are introduced, followed by the definitions and rationales of bilingualism and bilingual education. The significance of English language being the second language in Brunei education is briefly discussed in this chapter and this is followed by a comparison with the educational ideologies of neighbouring countries. The review also includes an examination of research that is related to the influence of the English language on science learning and boys’ and girls’ attitudes towards achievement with second language acquisition and use.

2.1 Background and Context of the Study

Brunei is the smallest country in Southeast Asia. Brunei is situated on the north coast of the island of Borneo and consists of 5,765 square kilometres with a population of 336,376 (The learning network, 2001). It has a coastline of 130 km between 114° 23’ and 115° 23’E by 4° 00’ and 5° 05’N. Its closest neighbours are the East Malaysian states of Sarawak and Sabah, while further to the northeast lie the islands of the Philippines, and stretching from the southeast to the southwest are the islands of Indonesia. Brunei is divided into four districts namely Brunei/Muara,
Tutong, Belait and Temburong. Bandar Seri Begawan is the centre of Government and business activities of Brunei.

Brunei is home to a complex distribution of ethnic and linguistic groups. Seven of these groups are considered indigenous by the state in Brunei today. These are the so-called *puak jati* (literally native tribes). Three of these groups, namely, the Brunei, the Kedayan, and the Tutong are totally Islamic, while another group, the Belait, is predominately Islamic, whereas the Dusun, Bisaya, and Murut groups are predominately non-Islamic. Each of these native tribes carries its own dialect. However, it is the Brunei dialect (Bahasa Brunei) of the Malay language that has retained force as a general *lingua franca* and thus is spoken by the people of Brunei in everyday conversation. This retention occurs because there is a deep view amongst the people that Brunei Malay best conveys harmony and social solidarity.

Standard Malay is the official language of Brunei. The Brunei dialect, however, has a profound influence such that it is even used in official communications. In schools, many teachers revert to explaining concepts in the Brunei dialect, rather than the standard Malay language. Furthermore, the local language is used freely in official briefings and speeches. Both the standard Malay and Brunei dialect are intelligible to the people of Brunei. However, the people of Brunei coldly accept standard Malay when used as an everyday language, such that a Brunei Malay will be labelled *sombong* (literally ‘arrogant’) if he or she speaks in standard Malay.

It is not necessarily superciliousness that is a barrier to the people of Brunei using standard Malay, rather, it has to do with confidence. Most people lack the confidence to use the language in standard form. In standard Malay, there are too many words that are not frequently used in everyday conversations in Brunei. Vocabulary from the Brunei dialect monopolizes the language in literature such as newspapers, magazines and popular books. Today, even classical Brunei writers spicce their Malay prose with idioms and colloquialisms from the Brunei dialect. The Malay language spoken in Brunei departs from its Peninsular analogue in two ways, first it incorporates aspects of the local Brunei dialect, and second, it has borrowed a ‘rich’ array of English. Such issues of language use are not peculiar to the Brunei context. The next section discloses some related issues of language use in societies in general.
2.2 Issues of Language Use in Societies

Language performs different purposes in the socialization process in communities throughout the world. Whatever the emphasis of social interaction, language plays a fundamental role in developing new ideas and personal relationships, upholding self pride and identity, unifying different groups of socio-cultural and linguistic backgrounds, and above all, in communication. Depending on the preferences and skills of a person and the nature of the communication, the kind of language selected to perform different functions varies. Moreover, there are continuous changes in language usage and the selection of language for various functions and components of the socialization process.

In many societies the language selected for various functions can be the home language, a language of the parents, or one of the parents in inter-lingual marriages. It can also be the local language, a language which is apportioned to unite a neighbourhood in multilingual societies. Often it is the case that neither the home language nor the local language is the same as the national language. Where a national language is thought to be lacking the necessary terminology and nuances to cope with functions at an international level, the use of a foreign language may be considered. The origin or choice of a language or languages for any kind of communication is very much influenced by the language of the school system and the medium of instruction must be designated by the government. This may involve the government in weighing carefully multiple orientations and factors of importance and is the fundamental rationale why some independent nations have felt obliged to immerse school children simultaneously in two or more languages.

People become bilingual when they acquire two languages at the same time in childhood, or by learning a second language sometime after acquiring their first language. The purpose of the next section is to develop definitions of bilingualism and bilingual education.

2.3 Bilingualism and Bilingual Education - Definitions

Kaplan and Baldauf (1997) define bilingualism as a situation when an individual is immersed simultaneously in two or more language communities. Rosenberg (1996)
claims that bilingualism has different meanings for different families. Depending on
the expectations of the parents, Rosenberg (1996) notes that the meaning of
bilingualism may be different from what linguists intend. Baker (1996) refers to
bilingual ability as a person’s language proficiency in its four basic dimensions of
listening, speaking, reading and writing as well as thinking. She suggests that a
bilingual person may either be fluent in two languages but tend to heavily favour
one of them or less fluent in two languages but switch between languages much
more frequently. Although definitions of bilingualism or the concept of bilingualism
vary in the literature, for the purpose of this study, bilingualism shall be defined as
the ability to speak, understand, read and write in two languages at a level where
exchange of communication is permitted, sequentially or simultaneously.

2.4 Rationales for Bilingual Education

The need for children and adults to acquire a second language can be traced to
various overlapping purposes. Baker (2001) has organised the rationales for second
language acquisition under three main headings: ideological, international and
individual that will be considered in the following sections.

2.4.1 Ideological reasons for bilingual education

Today, the majority of the world population uses only one of a few ‘big’ languages
such as English, Mandarin Chinese and Spanish. The acquisition and learning one of
the big, or majority, languages may be at the expense of minority languages. If this
situation continues, we are facing a natural momentum of eradication of many
‘small’ or minority languages (Diamond, 1993). Baker (2001) explains that the
learning of second languages will support the survival of small and minority
languages because the availability of second language instruction preserves and
maintains the existence of minority languages. This is important because harmony
and unity do not exist in a non-appreciative vacuum. Nor is harmony a consequence
of becoming a champion of someone else’s language at the expense of giving up
‘heritage’ cultures.

Brunei is originally a Malay country and is situated in the Malay region, therefore
should ideally establish a language policy common to her neighbouring countries.
The Malaysian constitution privileges Bahasa Malaysia as the national language. Indonesia's official language is Bahasa Indonesia. Both languages are intelligible to Bahasa Melayu or standard Malay speakers. It is also acknowledged that there is a need to acquire at least a moderate level of English language to equip Brunei's children with modern scientific advances and technological information. Pehin Dato Seri Setia Haji Awang Abdul Aziz, the Minister of Education, stated; "If we continue to teach in Bahasa Melayu (Malay language), we are certain to be left behind" (Gunn, 1997, p. 156). While the importance of the Malay language is respected, the Minister implies that to continue to exist in this modern world, the people of Brunei have to swallow their pride, consolidate, and use English in order to better appreciate the world of science and technology.

This shifting status of the Malay language and the English language in Brunei may be perceived as a state of confusion. However, it is unlikely that the Brunei culture will be threatened, as some people believe, by the use of English. The country's national identity and culture are firmly rooted and are able to withstand encroachment from a foreign language and the possible accompanying culture (Jones, 1990). In some ways, the accessibility of bilingual education in Brunei helps to maintain the survival of the Brunei culture.

2.4.2 International reasons for bilingual education

The linguistic situations in Singapore, Philippines and Malaysia indicate that political and social pressures can make second language acquisition at times crucial for harmony and equity within communities. The language minority speakers in these countries have to accept the existence of 'big' languages, which often are used as de facto working languages. This is what Baker (2001) describes as the most important international reason for second language acquisition because these 'big' languages are the languages used for economics and trade. Moreover, information on social, cultural, political and educational aspects of a nation are often only available in the form of these 'big' languages. As a result, countries with facilities in these languages are seen to welcome more economic activity as well as new knowledge, new skills and new understandings.
Brunei is a member of the Association of Southeast Asian Nations (ASEAN), The Asia Pacific Cooperation (APEC), BIMP-EAGA (Brunei, Indonesia, Malaysia, Indonesia, East ASEAN Growth Area), and many other international organizations. The current, official language of most of these organizations is English.

2.4.3 Individual reasons for bilingual education

Baker (2001) concludes that acquiring a second language will permit an individual to understand other peoples' cultural backgrounds. The importance and the role of each language and its close association with culture cannot be denied. As Diamond (1993, p. v) reports, "Each language is the vehicle for a unique way of thinking, a unique literature, and a unique view of the world". Rowan (2001) also believes that no language can be truly learned and appreciated without some knowledge about the people who speak that language. Fiorito (2000) suggests to educators that the study of a foreign language should be combined with the discovery of another culture. Jiang (2000) explains how culture and language are indeed inseparable. Based on this notion, Comtex (2002) expresses a concern that Kenyans, after decades of communicating in English, are probably losing their own cultural heritage. A language is, therefore, not the only thing 'lost' when a language becomes extinct, but also a culture. Loss of culture may even result in people losing their own history.

Oller et al. (1997) showed that bilingualism might be advantageous for learning due to a bilingual child's ability to function effectively in two cultures. Logically, children with a wider and varied range of experiences will acquire an extended range of meanings, extra cultural values and modes of thinking (Baker, 2001). As a result, bilingual children are often richer in their thinking habits compared with monolinguals. Poulos (1982) states that the advantages of a bilingual-bicultural educational system include the development of pride in ancestral culture, the improvement of self-concept and the ability to participate in two cultures. Learning in two cultures is also likely to provide the opportunity for each child to experience the world from two different perspectives, increase his or her awareness of cultural diversity and move the child away from a limited, egocentric point of view (Diaz, 1985).
Another individual reason for second language acquisition that Baker (2001) has suggested is that bilinguals can potentially build a social network with those who speak the second language. Finally, the ability to speak a second language is likely to open wider doors for career and employment opportunities because bilinguals are able to switch and speak the majority language in different contexts.

2.5 The Significance of English Language in Brunei Education

Language use in Brunei, as in all other countries and contexts, is not static. While many indigenous languages are in danger of being lost, the English language has slowly become a popular choice of communication in preference to the standard Malay. The standard Malay is attuned to Islamic and traditional values, while the English language keeps students of Brunei in touch with technological change. Based on this belief, Brunei independence on January 1, 1984, saw the introduction of the new National Education System. The new system replaced the dual system of separate English and Malay language medium schools with a system popularly known as the dwi-bahasa or the bilingual education system. A series of incidences in the 1950s and the aftermath created special problems for the provision of education services in Brunei. These incidences, particularly those that influenced the introduction of the bilingual system in Brunei, are explained in the next section.

2.6 Political Issues in Brunei that Influenced Language Use in Education

Malaysia was formed on September 16, 1963, and consisted of the Federation of Malaya, Singapore, Sarawak and North Borneo (now Sabah) (Shee, 1982; The National website, 2001). The Sultan of Brunei rejected membership in the Federation of Malaysia in July that year (Gunn, 1997). Apparently upset at the Sultan’s failure to join the Federation, Malaysia recalled hundreds of officers posted in Brunei in 1964. Malaysia also courted the Partai Rakyat Brunei (PRB) or Brunei People’s Party, the first political party formed in Brunei and more than likely was involved with the escape of Zaini, one of the leading lights of PRB, from prison in Brunei in July 1973. PRB staged a rebellion on December 8, 1962, forcing Brunei to declare a state of emergency. Malaysia’s complicity thus came as a surprise to
Brunei. At that time, most Brunei tertiary students were sent to Malaysia for further study. With deteriorating diplomatic relations with Malaysia, in November 1974, Brunei recalled all students studying in Malaysian higher educational institutions (Gunn, 1997; Jones, 1997). Thus, Brunei was left without an adequate tertiary education outlet especially for the Malay language medium students. Further, Brunei had no diplomatic relations with Indonesia, the only other country with Malay medium universities, so it could not send its students there.

Prior to this incidence, Aminuddin Baki and Paul Chang, two Malaysians, were invited to Brunei to design an education policy and principles based on the Malaysian system of education. This proposal was accepted and became the National Educational Policy in 1962. The failure of the political and diplomatic relations between Brunei and Malaysia caused the cancellation of the earlier proposal to adopt the Malaysian system of education and, as a result of the revolt, the implementation of the new policy was suspended. In the aftermath of the rebellion and the refusal of Brunei to join Malaysia, the National Educational Policy recommended by Aminuddin Baki and Paul Chang was never acted upon and the pre-1959 educational policies were continued (Jones, 1997, 2000b, 2000c).

The immediate problem facing Brunei as a result of the diplomatic rift was the lack of tertiary education for its Malay medium students. An instant solution was to send these Malay medium students to continue their studies in English speaking Universities in the United Kingdom. Despite attending a two-year English course at those universities, many students failed to achieve sufficient proficiency in English to get places on university courses. Even those who passed and were offered places, often struggled with their studies due to weak English language ability (Jones, 2000b).

It was because of this dilemma that Brunei eventually announced a new National System of education. Introduced in 1984 and implemented in 1985 by the Ministry of Education, this system of education is known as the bilingual education policy (dwibahasa). The bilingual policy is designed to ensure that children attain a high degree of proficiency in both English and Malay and thus are qualified to work in either English-speaking or Malay-speaking environments. Since 1985, all primary and secondary schools have adopted a common curriculum that incorporates two
school languages and the extent of the use of the English and Malay languages as the media of instruction is adjusted accordingly.

Today, the importance of English language in Brunei education is undeniable. Obtaining at least a pass in English language remains a prerequisite for entry to tertiary level education. Career opportunities also widen for those who have at least a credit pass in GCE ‘O’ level English language. Most application interviews and written tests for jobs in the government and the semi-government sectors are conducted in English. In some cases, internal reports are written in English and meetings are conducted in English. The English language used may not be perfect, but the tradition of using English rather than the Malay language is becoming commonplace. It is also common in Brunei to witness locals who refuse to respond entirely in Malay. They either mix the two languages in sentences or reply in broken English. In business circles, where the Chinese dominate most enterprises, Malay language has failed to win acceptance as the language of business, instead a Chinese dialect is used. The domain of English expands even further when expatriate labour employed as domestics, shop assistants of leading supermarkets and construction workers come from the Philippines and Thailand.

No matter how influential or powerful a country becomes, language will always be an important factor that has the potential to undermine the integrity of a nation. The most obvious and transparent solution for Brunei to avoid any type of language problem, so far, has been to encourage competence in other languages, or at least, to be bilingual. Even if this system does not provide the best solution, it will potentially prevent the development of linguistic handicaps.

2.7 Bilingual Education in Brunei

Following the implementation of the bilingual education system in 1985, two school languages, English and Malay, were used as the medium of instruction. It was anticipated that this system would enable all pupils in primary school to be able to learn both the Malay language and the English language. The use and application of the Malay language as the National language would be enhanced through the process of learning and teaching of several selected subjects in Malay.
languages and virtually no support at all for a system that offered either Malay or English exclusively. Bilingual education in Brunei, however, is far more complex than simply knowing two languages. For example, the Malay language used in classrooms is actually the standard Malay that is not the same as the Malay language used by Bruneians. There are words which have opposite or at least different meanings in the two Malay dialects. For example, the word ‘kita’, in standard Malay, means ‘us’, but in Brunei dialect, it means ‘you’. In addition, the grammatical ordering of words in most sentences or the syntax of both the standard Malay and the Malay dialect is generally different. To complicate matters even further, for many of the Brunei children, Malay (the Brunei dialect) is already their second language, depending on which indigenous group they come from. Brunei has seven indigenous groups which have their own languages or Malay dialects. As a result, many of these people would consider the standard Malay (the Malay language in the classroom) and English language as their third and fourth languages respectively (Jones, 2000c).

Given only three years grace period, Brunei children often do not master the standard Malay before the medium of instruction is changed to English in Primary 4. Worse still, there are many English words which are incorrectly translated into Brunei Malay dialect. For example, the word ‘condensed milk’ is understood by many locals as ‘susu manis’ or sweetened milk, and ‘evaporated milk’ as ‘susu cair’ or ‘diluted milk’. Most of the locals are very prone to translate English words to standard Malay before they finally translate it again to Brunei Malay dialect. Vice versa, they will translate many Brunei Malay words into standard Malay, before they eventually convert them into English words. In this course of action, ideas or meanings are lost or made more precise or exaggerated. Whatever the case, this process of translation will always occur in the current system because children are exposed to three years of standard Malay in their early years of schooling, before being expected to learn in English.

The policy of bilingualism in Brunei’s education system has been criticised by Davies (2000) who stated that despite good educational facilities, the calibre of education in Brunei remains low. According to Davies (2000), language is seen as the main root for this underachievement because many local teachers do not have a
sufficient command of English to offer effective instruction. Consequently, most school children never fully grasp English and, because insufficient time is given for the Malay language as a subject, students’ grammatical Malay also remains poor. James (1996) also expressed similar concerns regarding the unsatisfactory outcome of pupils having to learn a second dialect of Malay and then English as a second language to be able to participate in school.

Jones (2000b), however, reveals that in his 14 years first hand experience with local Brunei university students as an English lecturer, the students’ proficiency in English language during the tertiary period improved significantly, especially their oral ability. Writing remains a problem, but Jones’ major observation was that students gained confidence in their ability to use English. Gunn (1997) declared that the domain of English in Brunei has expanded under the impetus of the bilingual policy. If fact, he asserts that the domain of English speakers is expanding at the expense of Malay. There are many occasions when the people use these two languages to provide contexts for meaning in everyday conversation as well as in the classroom (Martin, 1999) Words like ‘mengexplain’ (explaining), clearly shows the combination of both languages. The function of the prefix ‘meng’ as used in Malay conversation is literally similar to the function of the suffix ‘ing’ in English. They both indicate that the act of that particular ‘verb’ is happening at that time. Not only is this custom accepted, it seems to be encouraged when there are no formal objections by instructors.

As far as the proficiency of Malay language is concerned, James (1996) suggests that too early and too sudden a switch from Malay-medium to English-medium teaching should be avoided. Further, he recommends postponing the switch until the Malay is well established in the child’s mind, for example until Primary 4. He does not, however, propose the delay of introducing English as the medium of instruction until secondary level. He indicates that the home dialect of Brunei Malay should be treated with respect in class because there are still too many words in the standard Malay that are never or seldom used in the people’s everyday conversation. Even to many adults, the word ‘pemeluwapan’ (condensation) is a very unfamiliar word and more so for small children in the lower and upper primary levels. Of interest in this study is whether or not this situation can affect the academic performance in science.
of bilingual primary children in Brunei? Before this issue is pursued, it is informative to explore the use of foreign languages and the effects of bilingualism on the development and education of other nations.

2.9 Other Countries and Bilingual Education

There are often political controversies in deciding whether to support the intrusion of any foreign language into the political development of a nation. Caught between realities and national pride, policy makers, somehow have to draw the line and a variety of decisions have been made with regard to language policy in Asian countries. In the following paragraphs, the policies employed by the nearby countries of Singapore, The Philippines, Malaysia and also The United States of America are considered.

2.9.1 Singapore

The complexity of the socio linguistic situation in Singapore has never been reflected in the choice of English as the working language. Malay may be designated as the national language but it is not taught as a compulsory subject in school for the non-Malays. In fact, it is not necessary for an individual to demonstrate proficiency in this national language to become a naturalized citizen of Singapore (Kuo, 1999). English is a non-native but neutral language because none of the major ethnic groups is at an advantage over the others when English is being used. Consequently, English language is preferred as the dominant working language for all official functions. Within the education system of Singapore, English is the only language taught in all schools and at all levels. Furthermore, the majority of core subjects are also taught in English. When a trend toward the use of English language among the younger generations became apparent in the second half of the past century, Singapore began to feel the effects of deculturalization. Responding to this dilemma, the Singapore government introduced the practice of bilingualism in 1987 (Mapzone, 1995). Under this policy, and in addition to the learning of English, all pupils must learn one of the ethnic languages, depending on the ethnic group to which the pupil belongs. The purpose of this policy is to encourage an appreciation of national pride and heritage (Ministry of Education, Singapore, 2000).
practice of bilingualism is introduced to the pupils in Singapore as early as in the first year of formal schooling.

2.9.2 Philippines

Unlike Singapore, the solution to the dilemma of choosing the language for schools was, apparently, obvious in the Philippines. The use of English for teaching started a century ago with the purpose of limiting the need for the Spanish language that had been used by the Spanish administration of the Philippines for more than three centuries (Pineda, 1981). It became evident, however, that those who were English educated became part of the elite as previously the decision makers were foreigners, and their influence, especially within the government, was strong. As a consequence, there existed two classes in the Filipino society (Pineda, 1981), those who spoke English and/or Spanish and those who were destined to be the followers. Since the Philippines' Independence in 1946, the national language, Filipino, was slowly brought into the school curriculum. The focus on Filipino was aimed at developing a sense of nationalism among the Filipino youth, to cultivate a national identity exclusive to the Philippines, and to significantly narrow the huge gap between those citizens who did not receive education and those who were English educated. Studies conducted revealed that the bilingual policy of 1946 was not effective (Espiritu, 2000). The English-speaking group continued to be powerful by retaining English as the language of instruction, predominantly in private schools. Nor was the Filipino language chosen for national functions. The battle continues despite the effort of the government to uphold the citizens preferred language, Filipino, as the language of instruction in schools. Statistics support the notion that the people prefer the Filipino language to English (Pineda, 1981). The statistics also may simply be a reflection of the fact that many of the people are actually fluent in only one language, Filipino. Whatever the reason, foreign languages such as English and Spanish have failed to become the dominant language of the Philippines. The education system, in particular, will have to improve the teaching of English and Filipino so that competence in both languages can be achieved. This is a very difficult and important issue because it centres on equity of access to education.
2.9.3 Malaysia

Malaysia can be said to be successful in bringing her citizens together to communicate with one national language, that is, Bahasa Malaysia. It is now 3 decades since the establishment of a national system of education which stresses the policy of using Bahasa Malaysia as the medium of instruction in schools. However, despite the contentment, Malaysia is now slowly experiencing the impact of falling standards of English. There is growing concern over the proficiency levels of English teachers as a result of the poor performance on English language examinations at the end of secondary school. A more serious issue is the existence of a gap between the urban and the rural populations (Pillay, 1998). The students from the rural areas have less exposure to English outside the classroom and this ultimately produces a lower level of competence in English compared with the students from the urban areas (Pillay, 1998). It is of great concern to the Malaysian government that serious, long-term implications may result for the people of Malaysia if this dilemma is not addressed immediately. Both the Prime Minister and the Minister of Education have continued to highlight the falling standards of English among the people, yet, the country has not made any move towards bilingual education.

2.9.4 Inference

Singapore, Philippines and Malaysia present situations where competence in only one language is just not enough. It is the English language that is the dominant 'other' language in these countries. The situation in these countries points to the question of whether it is possible for languages to co-exist with different uses, functions, and status? If survival is used to measure the capacity of languages to co-exist, then Singapore, Philippines and Malaysia are examples where this has been shown to be possible. But what is important about a language is more than just survival. Language is power. Kaplan and Baldauf (1997) state that "bilingualism is not a prerequisite for survival in many places, but – despite the evidence of a few communities – bilingualism constitutes the normal human condition" (p. 216). By and large, if there exists a monolingual society and the people can survive, then to be bilingual may not be necessary. This seems contradictory because while it is
‘normal’ to be bilingual it is not necessary for survival, however, bilingualism can give power to individuals. Ferguson in 1959 (as cited in Baker, 2001) distinguished between a majority and minority language within a country where different languages are used for different purposes and contexts. For example, the minority language is language used for home and family, social and cultural activity in the community, correspondence with relatives and friends and religious activity. The majority language, on the other hand, is used for schooling, media, business and commerce, and correspondence with government departments. These differences suggest that “one language [the majority language is] more prestigious than the other” (Baker, 2001, p. 45). Baker further emphasizes that, “it is typically embarrassing or belittling to use the low variety of language [minority language] in a situation where the high variety is expected” (p. 45). Finally, Baker concludes that the majority language is perceived as “the more eminent, elegant and educative language” (p. 45) that opens the door to “educational and economic success” (p. 45).

2.9.5 United States

It is difficult to imagine that America also experiences difficulty in immersing all of its children in English instruction. Also surprising is that the United States of America was once under pressure to unify the language used by its people because of the many indigenous languages and languages of immigrants. As a result, in 1919 English language was prescribed by the Americanization Department of the United States Bureau of Education as the language of private and public schools. Almost 40 years later, in 1957, the Russians launched Sputnik into space. An immediate reaction to this was a concern with English language being the sole language used in the education system. Baker (2001) stated that “For the United States’ politicians and public, a period of soul-searching led to debates about the quality of US education, US scientific creativity and US competence to compete in an increasingly international world. Doubts arose about the hitherto over-riding concern with English as the melting-pot language, and a new consciousness was aroused about the need for foreign language instruction” (p. 185). In 1958, the National Defence and Education Act (NDEA) passed a law permitting, as well as providing grants to support, the learning of foreign languages as a subject at all education levels (Baker, 2001). The introduction of bilingual education was an attempt to solve a problem,
however, new seeds of trouble were planted in the process. Most American Hispanic people, in particular, do not speak English (Mujica, 2000), and according to the census, from 1980 to 1990, the number of Spanish-speakers in the United States grew by 50% (Wallraff, 2000). Wallraff (2000) also claims that over the same period, the number of Chinese, Korean and Vietnamese speakers in the country grew by 98%, 127% and 150% respectively. Rothstein (1998) points out that their failure to learn English, especially the children, will leave them unprepared for the workplace. Worse still, a nation steeped in multi-culturalism must find a common bond to unite the people as Americans and to share commitment (Mujica, 2000). English language may not be the best general bond to unite all Americans, however, it is not without use either.

2.10 Bilingualism and the Age Factor

De Houwer (1999) explains that the process of acquiring two languages from birth closely resembles the primary acquisition of just one language. De Houwer (1999) further explains that even before the age of two, bilingual children are able to choose between their two languages both at the level of the conversation, as well as at the level of utterance, very much like adult bilinguals.

Learning a second language at an early stage in life has not been shown to be detrimental to either the development of the human being or the development of the language itself. Flege (1987) suggests that there is no conclusive support for the existence of a critical period for human speech learning. However, Olson and Samuels (1972) reveal that it is a common observation that children acquire better language pronunciation than adults. Seliger (1975) concurs that the age factor, rather than the learning situation, is the predominant variant in learning the pronunciation of a second language.

Nevertheless, ‘the earlier the better’ perception of second language acquisition portrayed above, is nothing more than a precaution to avoid the risk of losing an important window of opportunity. Bialystok (1997) claims that there is insufficient evidence to accept that mastery of a second language is determined by maturational factors. Singleton (1981) also concludes that the evidence for a general age-related deterioration in the capacity to learn a second language is scanty. Research shows
that there is no age difference in the speed of second language acquisition (for example, Fathman, 1975; Snow & Hoefnagel-Hoehle, 1975). In fact, there are studies that show that adults proceed faster than children in the early stages of language acquisition (for example, Collier, 1987b; Krashen et al., 1979; Olson & Samuels, 1972). In light of these variations, Schumann (1975) suggests that affective variables may be more important than maturation for learning a second language. Twyford (1987) and Banu (1986) propose that affective factors such as motivation, anxiety, self-confidence and the characteristics of the children also are important and may well be held responsible for the differences between adult and child language acquisition. Banu (1986) even challenges the methodological questions that are used in generalizing both the adult and the child performance.

If age factor is indeed insignificant in determining the chance of success of achieving second language proficiency, what hope is there that the use of a second language for the language of instruction in Primary 4 in Brunei will facilitate children's success in science? This is the issue that is the focus of this study.

2.11 Bilingualism and Cognitive Development

Apart from promoting intercultural sensitivity and awareness, it has been suggested that the learning of more than one language tends to support the development of cognition. Baker (2001) explains that bilinguals were historically regarded as having a relatively lower IQ than monolinguals. With more in-depth research on the relationship between intelligence and bilingualism, however, researchers are slowly moving towards more positive conclusions. The reliability of the earlier studies that showed lower IQ scores for bilinguals has been questioned. Baker (2001) explains that with the many serious methodological weaknesses in these studies, the negative effect of bilingualism on cognition can no longer be accepted. To the contrary, substantial research data since the 1960s has shown that fluent bilingualism contributes to the cognitive growth of children in terms of divergent and creative thinking, metalinguistic awareness and communicative sensitivity.

Although most researchers now purport that proficient bilinguals may have advantages in cognitive development, Latham (1998) asserts that this view is still not universally accepted. Some studies show that bilingualism does not affect
cognitive development (for example, Appel, 1989; Jarvis et al., 1995; Ransdell & Fischler, 1987). Baker (2001) argues that extreme negative and positive conclusions on cognitive functioning and bilingualism may both be untenable, but there are at least a clear majority of researchers who have found that the two are positively related. For example, Jacob and Pierce (1966) found that bilinguals are more creative than monolinguals. In a related study, bilingual children were found to be more advanced than monolinguals in solving problems requiring high levels of cognitive control of selective attention (Bialystok, 1999). Diaz (1985) also observed cognitive and academic advantages in bilingual children and later proposed that bilingual education is not only a culturally sensitive strategy, but also an excellent tool for enhancing the academic and intellectual potential of the children. A study by Hakuta (1987) also showed that there is a positive relationship between nonverbal intelligence measures and a degree of bilingualism in younger subjects. Fradd (1982) proposed to United States' educators that they consider bilingual education because of the potential of bilingualism to increase communication and greater problem solving skills. Finally, Kearsey and Turner (1999) present a study, which shows that being bilingual, with one language being English, was an advantage for understanding science because pupils could converse and think freely in both of their languages and much of the scientific vocabulary comes from English origins.

There is an assumption by many educators that the brain has a limited capacity. If this is indeed the case, then logically, the development of two languages will take up extra space in the brain, with less and less room for other cognitive abilities to develop. However, what appears as logic is not always psychologically valid. Baker (2001) suggests that it is wrong to assume that the brain has only a limited amount of room for language skills, such that monolingualism is preferable. He found that there appears to be enough cerebral living quarters not only for two languages, but for other languages as well. Visser (1996) concludes that learning can improve significantly if people succeed in using all parts of the brain. In an interview performed by Schardt (1997), psychologist Schaie explained that if the brain is not stimulated, the new connections that are necessary to maintain optimal mental functioning will not grow. It was proposed by Vaid and Hall in 1991 (as cited in Baker, 2001) that the left hemisphere of the brain is dominant for language processing for a first language and second language acquisition involves the right
hemisphere. If Vaid and Hall’s proposal is correct, it appears logical to conclude that bilinguals use a larger part of the brain than monolinguals and a positive relationship between bilingualism and cognitive development is likely.

The argument presented in the previous paragraph thus infers that bilingual children have accelerated cognitive development compared with monolinguals. If this is the case, we would expect Brunei bilingual children to progress in cognitive development as the primary level escalates. When poor linguistic and academic performance occurs in bilinguals, Oller et al. (1997) suggest that it may be associated with circumstances where the second language largely replaces the language at home; consequently, the mother tongue is allowed to wane, whilst the learner may never acquire native competence in the second language.

2.12 Gender and Second Language Acquisition

Children show different levels of proficiency in second languages despite being surrounded by the same contexts. When children appear to exhibit underachievement in the classroom, where should the ‘blame’ be placed? Blame may commonly be attributed to the child being bilingual (a claim, which research does not support). Other factors include lack of exposure to the majority language, mismatch between home and school, socio-economic factors, type of school, quality of education, and real learning difficulties (Baker, 2001). It could be possible that factors related to the child, the teacher, the school or the education system provide an explanation for underachievement. While it may hold true that the individual learner possesses individual differences, a question can be posed as to whether gender forms a major variable in second language acquisition?

Woolard (1997) claims that there is no gender difference in the pattern of second language acquisition or use and Callen (1981) found that sex is shown to be a relatively minor variable in language acquisition. However, Baker (2001) suggests that it may be possible to specify a list of factors that appear to be related to second language acquisition. For example, Baker claims that the age at which somebody learns a second language, their aptitude for learning languages, cognitive style, motivation, attitude, previous knowledge, learning style, learning strategies and personality variables such as anxiety, all potentially influence language acquisition.
It may also be possible that gender is a variable related to such personal characteristics.

Gardner (1968) claims that attitudinal motivational characteristics of the student are important in the acquisition of a second language. Sutarso (1996) confirms the presence of a link between attitudes and foreign language learning. Attitude and motivation for learning a second language, on the other hand, is said to be independent of aptitude and general intelligence (Taylor, 1973). Likewise, studies have shown that gender difference is a variable influencing attitudes (for example, Cokley & Wright, 1995; Felder et al., 1994; Togrol & Onur, 2000; Whitelaw, Milosevic & Daniels, 2000). Thus, it can be argued that if a reciprocal correlation exists between attitudes and gender, is it possible that gender influences the learning of a second language?

There is considerable research that supports the argument that gender is a variable affecting language learning (Oxford & Ehrman, 1992). A study by Wright (1999) shows that gender is the strongest predictor of attitudes toward learning French and French culture, a foreign culture for the British students studied. Clark and Trafford (1996) found that boys attach less importance to learning a foreign language than girls. In an attitude survey of 12-year old students in the United Kingdom, Powell and Batters (1985) showed that girls are more likely to favour studying French or German than boys. Shaaban and Ghaith (2000) show that female students in Lebanon are more motivated than males when learning English as a foreign language. Abu-Rabia (1997) concludes that Arab females were more interested than males in being integrated into Canadian society. Martin (1994) explains that there is a general trend in Australia that indicates that boys are more likely than girls to discontinue their study of languages and less likely to excel in the language class. Powell (1986) acknowledges the declining language enrolment among boys in Great Britain and suggests that to promote second language education, formal elements and variables have to be examined. Studies by Ekstrand (1976), Clark and Trafford (1996) and later, Abu-Rabia (1997), show that sex differences in individual factors enhancing second language learning are all in favour of girls. Women are claimed to possess several advantages over men in the acquisition of foreign language (Kahlke, 1996). Nyland (2001) shows that in one Australian study, boys appeared to be
behind girls on most measures in language acquisition. Hertel (1996) found that
dfemale pupils easily outnumbered their male counterparts in the foreign language
proficiency competition. This does not mean, however, that girls are better language
learners.

Some research does not support the notion that girls achieve better in language
acquisition. For example, a study that explored children’s attitudes toward French,
found that as the pupils moved from middle to high school, girls’ attitudes, more
than the boys, became negative and tended to become more ethnocentric (Morris,
1978). In a study by Cross (1983), boys were not found to be weaker in any of the
language skill areas tested. Edelenbos and Vinje (2000) show that Dutch boys
outperformed girls in an assessment on English as a foreign language. Morrison and
Wightman (1983) found that in a French second language skill assessment program,
even though very few sex differences were observed, a disproportionately small
number of boys were seen to achieve higher mean scores on some measures than
girls. Blom et al. (1980) suggested that boys are not ‘deficit’ in language ability and
the difference is due to the poor reading performance of boys.

A study by Weinburgh (1995) found that boys show a more positive attitude toward
science than girls and that a positive attitude results in higher achievement. Christ
(1996) explained that girls may dominate foreign language disciplines, but boys are
seen to more frequently enter the fields of mathematics and natural sciences. Bugel
(1994) claimed that females’ preference for language has made it difficult for boys
to outperform them on examinations containing written items, even those oriented
toward science and technology.

Abu-Rabia and Feuerverger (1996) suggest that in language education, it is essential
to develop pedagogies that respond to the diversity of the social contexts in which
the learners are situated. Ultimately, this opens doors for more variables other than
just the children’s characteristics that affect the learning of a second language.
Hendrick and Stange (1991) found that while boys interrupted teachers more than
girls, teachers interrupted girls more than they did boys. Sunderland (1998)
recognized that girls tend to create their own learning opportunities by utilizing
those provided by the teacher. Place (1997) claimed that boys’ failure to progress as
well as girls in high school modern foreign language subjects is because boys’
specific needs are often insufficiently addressed. Barton (1997) encourages teachers to acknowledge individual differences that are found to contribute to boys’ unsatisfactory foreign language achievement such as parental influences, dominant role models, teacher expectations and attitudes towards specific languages, and to adapt their teaching methods where possible and appropriate. Loulidi (1989) concludes that the sex-based imbalance in foreign language enrolment is directly related to the attitudes of its society as a whole toward gender roles. Gardner, Masgoret and Tremblay (1999) report that sociocultural experiences influence students' cultural attitudes, motivations to learn French and self-perceptions of second language proficiency. Finally, students who speak a language other than English at home are shown to have more positive attitudes to language than those who do not (Zammit, 1993).

There are other individual psychological factors that are important in second language learning, for example, language shock, anxiety and stress. These factors, together with the other individual differences as well as the environment for learning, provide dimensions that may determine the amount of new language being acquired. A paradox is observed when gender is thought to be a variable for learning a second language. This view is clearly not supported by research. Ironically, where underachievement exists, the spontaneous reaction, in some social situations, particularly in Brunei, is to apportion blame to the sex of the learner. This study will examine gender difference and the influence of acquiring a second language on their science understanding. It will examine whether both male and female children in Brunei progress approximately at the same rate in science understanding.

2.13 English Language and Science Learning

Some 380 million people speak English as their first language, perhaps two-thirds as many again as their second language, a billion are learning it and about a third of the world’s population are in some sense exposed to it (The Economist, 2001). It is also predicted that by the year 2050, half the world will be more or less proficient in English. For 200 years before World War II, German was crowned as the most important language in the world (Eisenberg, 1992), however, dramatic changes have taken place in the past half century. English is now clearly the predominant ‘world’
language. This is indicated by more recent changes. For example, Earth Island Institute (2001) announced an agreement made by The European Commission (EU) that English would become the official language of the EU rather than German. Wallraff (2000) declared that English is the official language of the European Central Bank, even though the bank is in Frankfurt and neither Britain nor any other predominantly English-speaking country is a member of the European Monetary Union. English also is the working language of the Asian trade group ASEAN. In bilingual education, English is the preferred ‘other’ language in all Asian countries (Tickoo, 1996). English is a neutral language through which none of the major ethnic groups in Asia is at an advantage over another.

A report by the Nuffield Foundation (2000) argues that despite the fact that English is becoming a dominant language in the world, knowing only English is not enough. This, inadvertently, supports the idea of bilingualism as practiced in most parts of the world. Aside from being an important asset to business (Canadian Chamber of Commerce, 1977), bilingualism can have a positive effect on the ability of students to formulate scientific hypotheses or solutions to science problems (Kessler & Quinn, 1980, 1981). Kessler and Quinn (1980, 1981) found that children in bilingual experimental groups, where one of the languages was English, performed significantly better than the monolinguals. Similarly, Sutman, Guzman and Schwartz (1993) indicated that a preschool science curriculum that includes English instruction could help young children overcome many obstacles to learning. They also revealed that Limited English Proficient (LEP) students’ performance in completing college degrees drops significantly and continuously, especially in the sciences, compared with non-LEP students. Kearsey and Turner (1999) provide evidence which shows that being bilingual may confer an advantage on pupils in science classrooms. Finally, Fouzder and Markwick (1999) found that bilingual students made significant progress in their learning of science concepts. These studies verify that being bilingual or learning a foreign language tends to endorse the development of cognition.

The influence of language and culture on learning science has been investigated by several researchers and educators. Rollnick (1998) agrees that both language and culture are essential for the effectiveness of science learning. Research evidence
suggests that dropout and illiteracy problems may be based on a refusal to consider the role of language and culture in the learning process (Rincon & Ray, 1974). The work of Hewson and Hamlyn (1983) also demonstrated that culture can provide a source of scientific conceptions. Unfortunately, not all commentators are enthusiastic about acquiring languages other than the English language. This is largely because English is not only the language of international business, politics and diplomacy, it is the language of computers and the Internet and most importantly, the language of science.

The reason why English is the language of science is complex, however, recently the connection can be attributed to the recent economic prowess of the United States. Post World War II, the United States economy boomed. As a result, more money was poured into research and development. The United States scientists flocked to conferences, bringing with them their language. Their publications burgeoned and eventually scientists throughout the world came to realize that English was the medium through which the materials could be read and cited. With technical dominance, came the beginning of linguistic dominance, first in Europe, then globally. Since then, English has gradually become the *lingua franca* of science (Eisenberg, 1992; Kaplan, 1998). Djite (1995) claims that the spread of English is a consequence of United States dominance in technology. For French scientists, the unwritten criterion for promotion at the Centre National de la Recherche Scientifique is to publish their papers in English (Bader, 1992; Hellemans, 1992). The Institut Pasteur, the French national medical research flagship, has been quietly publishing in English since the early 1980s. It even changed the titles of three of its publications from partly French to all English (Hellemans, 1992). The growth of English readers was cited as the main reason for switching to English. Brown (1980) reported that the thirty journals regarded as most useful to scientists are all now written in English. Consequently, people who want to maintain knowledge of recent advancements in a specialization of science or wish to understand science ideas will have to learn the dominant language of the field.

The status of English as the accepted international language of scientific research has been questioned, especially with regard to the difficulty for non-native speakers to publish their work in English. However, from the data gathered by Garfield and
Welljams-Dorof (1990), based on the publications by both native and non-native speakers over the period from 1984 to 1988, it was found that nearly 900,000 items support English as the predominant language of science and research. Grabe (1988) concludes that no country can afford to ignore the important role English plays in information access and technology transfer because English is the major international language that dominates world communication in science and technology.

English has an unusually rich vocabulary particularly in science and technology. However, Eisenberg (1992) argues that it was scientific leadership, not a flexible lexicon that sparked the diffusion of English. Nevertheless, the lexicon of the English language happens to suit scientific communications particularly well. Buck, Dent and Umpleby (2000) report that English language is the key to explaining scientific concepts more clearly. Torres (2000) found that high order English language proficiency combined with high levels of reasoning skills enhances students’ abilities to learn science content subject matter. Since communication is a core aspect of the scientific method, scientists take special care in writing reports and presenting information concisely and precisely. For this purpose, Brown (1980) proposed that English emerged as the most suitable language Rollnick (1998) claimed that English language is still regarded as crucial for communication of science internationally and for explaining clearly the concepts of science. Isa and Maskill’s (1982) analysis demonstrated that many languages do not possess the words for scientific concepts and produce inappropriate associations when invented words are used. Strevens (1969) also found many languages lack the logical connectors so essential to the teaching of science.

Clerk and Rutherford (2000) confirm that language confusion may be detrimental for learning science, however, language problems sometimes masquerade as scientific misconceptions. They argue that if a student is found to answer questions incorrectly, teachers often jump to the conclusion that true scientific misconceptions are held. This would demand the teachers use conceptual change strategies, which would be unproductive if the problem is one of language rather than of conception. Not only must language become a matter for consideration in diagnostic and remedial situations, the role of language during instruction must be carefully
examined. Curtis and Millar (1988) concluded that the differences of conceptual understanding in science can best be attributed to general fluency in the language of instruction. Further, Rollnick (1998) asserted that the use of the home language can lead to the emergence of alternate conceptions.

Thus, learning in two languages may result in the development of alternative conceptions, apart from children's own misunderstandings of concepts. However, misunderstandings in science may come from many sources which include language used in textbooks (O’Toole, 1996), diagrams in textbooks and the culture of the classrooms. Peacock (1995) found that textbooks are often too difficult for children, particularly in developing countries where pupils are learning science with English as the medium of instruction.

In Brunei, the limited second language used by teachers and students to discuss scientific ideas might become a potential source for the development of alternative conceptions. In many cases, English words are incorrectly translated into Malay and scientific words are often not used at all in everyday conversations. This study thus gains much of its impetus from the negligence of Brunei's science education community to the notion of the importance of language in science teaching and learning.

2.14 Summary

This first chapter of the literature review examined the issue of language and education. The language theme was developed to provide a broad literature base for the hypothesis that language is a major factor influencing conceptual development and science learning in Brunei. On one hand, various advantages of bilingualism were considered, in particular, the importance of English being the 'other' language in the context of acquiring a second language. On the other hand, this chapter has considered the potential disadvantages for students of not having English language instruction. There is strong evidence that regardless of the pitfalls of the sudden change in the language of instruction in Brunei, English language instruction puts the students in a position of advantage in the longer term. The next chapter discusses the literature that informed the development of the theoretical framework for this
study. In particular, Chapter 3 focuses on the literature about conceptual development, conceptual change and science learning.
CHAPTER THREE

TOWARDS A THEORETICAL FRAMEWORK:
CONCEPTUAL DEVELOPMENT AND CONCEPTUAL CHANGE

3.0 Introduction

The second half of the literature review is presented in this chapter. The literature relevant to the construction of a theoretical framework is examined with a focus on the theory of conceptual change, a theory that is closely linked with and reflects the process of conceptual development. The theoretical framework draws on this analysis of the literature and is presented at the conclusion of the chapter. Research about children's understanding of concepts related to evaporation and condensation and living and non-living things also is reviewed in this chapter. The context of this study is initially made explicit, however, through the consideration of the status of science learning in Brunei.

3.1 Learning Science in Brunei

In order to secure better prospects for both higher education and career, students in Brunei need to acquire English language proficiency at a high level. In addition to English language proficiency, the opportunities for students widen as they do well in the science subjects. Science plays an important mediating role in determining career paths, with students who do well in science often entering prestigious and highly remunerated occupations. English language proficiency and high science achievement are, therefore, both highly valued and critical components in the overall education of Brunei students. The high status of both these aspects of students' education creates tension because the focus on achievement of English language proficiency seems to have the undesirable effect of lowering science achievement. This tension has been recognized and conveyed through recent key-note speeches by key ministerial members.
In an address at the International Conference of Science and Mathematics, a former Permanent Secretary of the Ministry of Education of Brunei, Dato Paduka Hj Ali Hashim (Ali Hashim, 2001), revealed that the Ministry of Education was embarking on a program of encouraging more students to take science at the upper secondary level. The rationale for this direction was that the country’s future depends on its citizens having adequate knowledge and skills in science and technology. He disclosed that, based on a study carried out in 1995, three major points of weakness in science education in Brunei had been identified. First, the overall performance in science subjects for the Brunei Junior Certificate of Education (BJCE) (now Penilaian Menengah Bawah or PMB) appeared to be consistently low. Second, students have poor attitudes towards classroom activities and practices despite expressing an interest in learning science. And finally, the practice of teaching in Brunei was primarily to serve examination purposes and thus limited the real intention of teaching and learning science.

Another former Permanent Secretary of the Ministry of Education, Pehin Dato Hj Abu Bakar, speaking at the closing of the Science and Technology week 2001, disclosed that the percentage of local students interested in pure science subjects at secondary and advanced level was alarmingly low (Diolata, 2001). In addition, he suggested that poor English language proficiency, especially at government schools, might be one of the factors related to the lack of understanding among primary students in science subjects.

The concerns of the Brunei Ministry of Education about the underachievement of a large percentage of primary pupils in science have been documented in the literature (Lim, Suntharalechmy & Salleh, 1999). Moreover, the concerns about science underachievement and a link with English proficiency levels are supported by research. For example, Heppner, Heppner and Leong (1997) found that the performance of ‘A’ level students in Biology was relatively low in the mid 1990’s. One of the reasons, they claimed, was that students found the English language reading materials supplied to them too difficult. Similarly, O’Toole (1996) associated student difficulty in learning science with the language style used in school textbooks. The scientific style of English used by writers and scientists to produce textbooks is influenced by the values of their own communities and
O'Toole explained that this can be a barrier to those who are outside these societies. Heppner et al. considered the primary education system in Brunei to be the origin for many students’ problems in reading and expression in English. These researchers pointed to data that demonstrates that many local teachers do not have English as their first language and that instruction is often a mixture of Malay and English. Their argument also implied that undesirable academic performance in other subjects, such as science, may be a result of the perpetuation of English language deficiencies from one level to the next.

Martin (1999) found that during the teaching and learning of science in two upper primary schools in Brunei, teachers and pupils used English and Malay to unpack the meaning of written material in textbooks. He revealed that during science lessons, the teacher nominated individual pupils to read from the text. At regular intervals, the teacher stopped the reading performance in order to describe and annotate the text in both languages. The issue of how such language switching might best contribute to learning in the classroom remains largely unresearched at present. Martin argued, however, that, at the very least, talk should be the most useful resource for learning science.

On top of the concerns of the Ministry of Education and the difficulties highlighted by research, teachers and parents in Brunei also have voiced their concerns about the difficulty for students who are required to learn science with poor English language skills. A teacher, who wished to remain anonymous, recently sent a short letter to the Brunei daily newspaper, Borneo Bulletin, expressing his or her worries and sadness regarding the level of English proficiency among the Brunei children today. The writer, simply known as ‘Education Officer’ (March 19, 2003), wrote that,

The [Brunei] young children today are being taught to think in Malay and trust me; it will become very difficult for them when they reach the upper primary. They will be bombarded with English words and sentences telling them about the facts of life. It won’t be six-worded sentences where all they have to do is fill in the blanks with the plural or simple past tense of so and so. (p. 4).

Three days later, ‘Parents-In-Distress’ (March 22, 2003) wrote to the same newspaper voicing their support of ‘Education Officer’s’ concerns. They contended
that, "the English language is an international language written and spoken all over the world – a great necessity in our lives" and, "we parents suffer in silence when we listen to our children speak in broken English – with tense all hay wired" (p. 4). The significance of this public outcry is that there is considerable national concern in Brunei about children’s poor English skills and the associated poor achievement in science.

In addressing the issue of low-quality achievement in science for Brunei students, there is a need to explore, in greater depth, students’ understanding of science concepts. The following sections review the literature relevant to the science concepts selected as the focus of this study.

3.2 Concepts Taught in Brunei Primary Science

In order to investigate the relationship between language use and the learning of science in Brunei primary schools, two clusters of science concepts were selected. The first cluster centred around the concepts of evaporation and condensation and the second cluster centred around the concepts of living and non-living things.

Evaporation and condensation are not explicitly taught in the school curriculum even though rain and evaporation and condensation are a natural daily phenomena in Brunei. It was anticipated, however, that peer and family interaction, as well as school experience, would provide the children with rationales for explaining the phenomena. The concepts of living and non-living, on the other hand, are included within the only topic that is taught continuously from Primary 1 to Primary 6 in the Brunei science curriculum. The choice to include these concepts was to create two different contexts for analysing conceptual change, one with concepts not taught at school, the other with concepts taught extensively at school. In the following sections, research that investigated pupils’ understanding of these clusters of concepts are reviewed.

3.2.1 Children’s conceptions of evaporation and condensation

To Brunei children, having water and then to ‘lose’ it is not a foreign experience. Brunei children are exposed to the processes of evaporation and condensation on a
daily basis because rain is a common, natural phenomenon for people in this country. Bentley (1995) indicates that as a result of everyday experiences, children spontaneously construct ideas that help them interpret how things work in the natural world around them. There is a considerable literature base that explores children’s understanding of evaporation and condensation (e.g., Bar, 1989; Chang, 1999; Johnson, 1998; Taiwo, Motswiri & Masene, 1999; Tytler, 1997; Tytler, 2000; Tytler & Peterson, 2000a, 2000b). None of this research specifically investigates Brunei children’s understandings of these concepts, however, there is a great deal of information presented in the literature that provides insight into young children’s understandings that are relevant to this study.

The water cycle has been identified as one of the most important natural phenomena for primary school children to understand because of the significance of water to humankind (Bar, 1989; Taiwo et al., 1999). Understanding of the water cycle needs, as its pre-requisites, the understanding of the concepts of evaporation and condensation. Evaporation itself is a complex scientific topic for primary school children because it requires an understanding of other concepts such as air and matter, and interrelationships between entities such as the atmosphere and clouds, the sun, heat and surfaces (Tytler & Peterson, 2000b). Further, an understanding of evaporation and condensation requires an understanding of the abstract concepts of the particle model of matter and phase change between the states of liquid and gas. The topic of the evaporation phenomenon is significant from a developmental perspective because it involves the change of water from a state in which it can be perceived through vision and touch to a state in which neither is possible (Bar & Galili, 1994).

When the complexity of conceptual interrelationships required for an understanding of the water cycle is taken into consideration, it is not surprising that even though it is a common natural phenomenon, misinterpretations of this process by children are frequently reported (Bar, 1989). Examples of misconceptions reported by Bar include: “the clouds are kept above the sky” (or “in the sky”); clouds are “bags of water” and “rain falls when clouds open” (p. 489). Chang (1999) adds that pre-service elementary teachers also seemed to have alternate interpretations of these
concepts. For example, the “white smoke was water vapour” and “the idea that water vapour is invisible is only a theoretical assumption” (p. 524).

Bar (1989) found that the explanations for rain typical of children aged between five and 10 years in Israel included the ideas that; clouds are sent by God or come from another place, clouds are made from the vapour of kettles or are created from the sun boiling the sea and clouds are refilled by sea water. Some children also said that clouds are made of heat. For the older pupils from 9 to 15, the two most frequently expressed scientifically correct explanations were; clouds are created from vapour coming from many sources and the source of the clouds is seawater evaporated by the sun. As for the mechanism of rainfall, the young group of children tended to explain that rain comes from colliding clouds. Moreover, about 20% to 30% of the participants between the ages of 7 and 14 years in this study still held this view. The explanation that rain falls when the clouds become cold or heavy was found to be the most frequent idea expressed by the children from the age of 10.

Taiwo et al. (1999) asserts that several age groups of African pupils often misinterpreted everyday or common natural phenomena such as evaporation and condensation because of their prevailing worldviews. He found that the perception of the water cycle held by primary school children in Botswana was dominated by pseudo-scientific knowledge. Some of the pseudo-scientific explanations about cloud formation included; clouds are formed by water in the air, the movement of clouds causes rain; and rainbows are caused by wind after rain. Their perceptions were also coloured, to some extent, by their cultural beliefs such as clouds come from heaven and clouds are made by Gods. Even though Taiwo found that there was no gender difference in the perception of the water cycle among the primary school pupils, he found that the higher the grade level of the pupil, the more scientific the explanation. Taiwo concluded that pupils aged about 9 years tend to operate at the pseudo-scientific level, and that pupils aged between 10 and 13 years gave explanations that were more structured and thus more scientifically correct.

Bar (1989) proposed the existence of structured schemes that represent three stages of development of children’s ideas of evaporation and condensation. Level I refers to conceptions dominated by primitive or cultural beliefs. For example, that clouds are created from vapour coming from a kettle and that clouds contain bags of water
which open up to form rain. Many young children, mostly aged between five and seven, were categorized under this level of understanding. The children’s progress through Levels II and III was described by Bar as a development from a concrete to a more abstract form. Level II started at about the age of seven with a range up to about age nine. Here the children’s perception of the water cycle is pseudo-scientific in nature, for example, they believed that the sun ‘boils’ sea water to form the clouds and clouds are shaken up by the wind to cause rainfall. At Level III, the scientific idea that water changes into vapour through evaporation is understood. While a few younger children were observed by Bar to be at this level, older children aged between nine and 15 dominated.

Russell, Harlen and Watt (1989) did not observe the three levels of understanding described by Bar (1989) in the context of their research. Rather, they showed that a great majority of children aged between five and seven simply focused on water dripping to the ground to explain the drying of clothes. The eight to 11 year old children, interestingly, were no better than the younger groups. The responses of these children implied that the water in wet clothing just soaked into the cloth and was being ‘held’ there.

In more recent studies, Bar and Travis (1991) and Bar and Galili (1994) found that until the age of approximately seven years, children tended to consider that water simply disappears during the process of evaporation. At about the age of nine the children in these studies considered that water is transferred upwards, to the sky or ceiling or clouds.

When focusing on the process of boiling with a group of children of the age range six to 12, Bar and Travis (1991) found that some children from a young age had an almost correct view, however, they confused steam and vapour. Bar and Travis also asserted that children’s understanding of boiling followed certain progressive stages, from the idea that water penetrates through solid objects to the more scientific view of the evaporation of water. Children’s ideas about the nature of the matter inside the bubbles in boiling water progressed from the incorrect view of air to the correct view of gaseous water. Bar and Travis also explored ideas of condensation. However, the question used by these researchers, ‘can vapour change into water?’
failed to make a distinction between atmospheric water vapour and the misty steam from boiling water. Children’s thinking was, therefore, not clearly ascertained.

Bar and Galili (1994) further described children’s understanding of evaporation and condensation with age in terms of a sequence of four views. The four distinct views were:

A – Water disappears
B – Water is absorbed by the floor (or/and ground)
C – Water ‘evaporates’, meaning it is now unseen and being transferred into an alternative location or medium, etc:
D – Water changes into vapour, as small (commonly unseen) droplets, dispersed in the air, or water is transformed into air.

Bar and Galili (1994) demonstrated that over the age span of 5 to 14, children’s understanding progresses through the sequence of views $A \Rightarrow B \Rightarrow C \Rightarrow D$. They identified view $A$ as the most popular conception for the younger age groups. The percentage of children holding this view decreased as the age increased. View $B$ was common for children between ages seven and eight, however, some children in this age group already held view $C$. By the age of 12, as many as 60% of the children were able to reason with view $C$. View $D$ started to appear only at ages older than nine and a half. Bar and Galili also offered an additional category $E$ which represented children who were able to use ideas about the conservation of matter. By about age 12 to 13, children primarily employed three views about evaporation, that is, view $A$, $D$ and $E$.

More recently, however, Tytler (2000) and Tytler and Peterson (2000b) have challenged Bar and Galili’s (1994) so-called strictly developmentalist sequence. While agreeing that the most complex explanation in the series of Bar and Galili’s chain of children’s responses, $E$, represents an age-related advance for the children, Tytler (2000) and Tytler and Peterson (2000b) believe that the earlier ‘stages’ were all substantially drawn upon by each child, of whatever age. Tytler (2000) identifies a mix of conceptions on evaporation and condensation by Year 1 (5 and 6 years old).
and Year 6 (10 and 11 years old) children. According to Tytler, the mix is hard to entangle because of the ambiguity of language. Children tend to use words or phrases like ‘evaporate’, ‘moisture’, ‘vaporised into the air’ or ‘the coldness causes moisture’ which may act both as powerful descriptors and a source of vagueness. There seemed to be a substantial overlap between the conceptions used by Year 1 and Year 6 children.

Tytler (2000) confirms that Year 6 children showed greater confidence about the general notion of water exchange with the air than Year 1 students, particularly in their explanations of condensation phenomena. The older children seemed to have far more specific knowledge of other concepts to support their theory about these phenomena. It is interesting to note that contradiction exists between Tytler’s and Bar and Galili’s (1994) findings in terms of the number of children using the displacement conception, that is, that liquid changes position but not form. The use of the displacement conception is much lower in Tytler’s study involving Australian pupils than Bar and Galili’s research with Israel pupils. The percentages for the 6 and 11 year old pupils using the displacement conception are 6% and 8% for Tytler’s study compared with 40% and 25% for Bar and Galili’s research. Tytler proposed that the difference could be attributed to the fact that children in Australia are exposed to the teaching of the water cycle earlier than Israeli pupils, or that the mixture of contexts in which they responded encouraged them to have better images of the phenomena. Butterworth, Siegal, Newcombe and Dorfmann in 1999 (as cited by Siegal & Peterson, 1999) reported that Australian children are generally advanced in their geographical and astronomical concepts such that preschoolers often express the scientific beliefs that the world is shaped as a sphere, one cannot fall off the edge and that the earth goes around the sun.

3.2.2 Children’s conceptions of living and non-living

Several researchers have investigated the development of children’s conceptions of living, and the related concepts, in particular focussing upon the changes in children’s reasons for attributing life to objects (Bell, 1981; Bell & Freyberg, 1985; Carey, 1985; Coley, Medin & James, 1999; Driver, Squires, Rushworth & Wood-Robinson, 1994; Inagaki & Hatano, 2002; Lucas, Linke & Sedgwick, 1979. Piaget,

Understanding the concept of living things is fundamental to having a biological theory (Carey, 1985; Siegal & Peterson, 1999) and a prerequisite to being able to successfully participate in all biological lessons and learning activities. It is not surprising, therefore, that the topic of ‘Living Things’ is included in the early years of schooling in Brunei and most other countries throughout the world.

Much of the research that has focussed on children’s understanding of the scientific concept of living has extended from initial interviews by Piaget. Piaget (1979) claimed that young children less than six years old tend to identify objects as living when they are observed performing similar functions and activities as living kinds. Children’s conceptions of living things are later narrowed to apply only to objects that show some kind of movement between about seven and eight years. According to Piaget, this is followed by a stage between eight and 12 years, when things that are ‘self-starters’, or things that can move by themselves, are considered as ‘alive’.

In an attempt to investigate the conception of ‘animals’ that pupils hold, Bell (1981) explored 39 average ability pupils’ understanding of the broader concept of living. She found that many students between the ages of 10 and 15 have a restricted concept of ‘animal’ compared with that of a biologist. Ninety percent of the pupils interviewed by Bell could not classify all the animal instances discussed correctly, nor did the pupils know or use the scientifically acceptable criteria for animals. Moreover, only a few pupils were able to correctly categorize small creatures, such as insects, as living. Similarly, Trowbridge and Mintzel (1988) found that many elementary and secondary students in their study, and even biology non-major and major university students, tended to apply the label ‘animal’ almost exclusively to vertebrates. Bell (1981) also found that the pupils in her study were influenced by the conception that only four-legged mammals are animals. As a result, they tend to use the word ‘animal’ in a way that is synonymous with the word ‘mammal’. For these pupils, all other animals, which are not mammals, fall under different categories such as insect, fish or bird. Bell later concluded that the difficulty lies not in the complexity of the scientific meaning but with the confusion between the common and scientific meanings the children have.
The word 'animal', as Bell (1981) explains, is commonly used in biological texts and lessons and also is a label for a concept basic to the study of biology. However, Bell claims that students are confused about whether the word 'animal' is a label for a concept that is scientifically accepted or whether it refers to a different concept or meaning used in everyday contexts (Bell, 1981). What is clear is that what scientists interpret as the meaning of 'animal' is not how it is interpreted in the everyday sense. For example, the sign, 'No animals allowed', as shown in many shops in Brunei and on freeways in Australia, in a scientific sense would mean that human beings are not allowed in these places. Most people interpret this signage to mean that no 'pets' are allowed inside and thus it seems that in everyday use people are not animals!

Like Bell, Carey (1985) maintained that young children are novices in many domains in which adults are experts including their understanding of the concepts of living and animal. According to Carey, young children are more interested in differentiating between alive and dead than alive and inanimate. However, as they do not yet understand death as the cessation of bodily function, young children tend to rationalize with other criteria such as "real and imaginary, existent and nonexistent, and functional and broken" (p. 182).

The notion of 'life-theorizers' was used by Slaughter, Jaakkola and Carey (1999) to describe pupils who can give "specific functional explanations such as 'the heart is breathing' and 'the brain is for thinking'" (p. 81). They found that half of the young children aged between four and five years in their study were not yet 'life-theorizers' (p. 92). Jaakkola in 1997 (as cited in Slaughter et al., 1999) claimed that virtually all of the 6 to 10 year old children in her study were life-theorizers. The potential of being life-theorizers appears to unfold as the children begin to construct a vitalistic theory of the human body (Slaughter et al., 1999). Vitalistic theory reflects the intentional explanations of, for example, why we need food. A life-theorizer's explanation would be "because our stomach takes in vital power from the food" (Slaughter et al., 1999, p. 79). Slaughter et al. found that the vitalistic theory of the human body starts to appear when children are between four to five years old. As the children's conception of living appears to develop as a result of changing their focus from an animistic notion to the biological goal of living things, Slaughter et al. claim
that "it is no coincidence that these concepts (children’s conception of living and death) change around the same time" (p. 92). As a result, Slaughter et al. claimed that the concepts of life and death will, therefore, develop from as early as four to five years of age.

In understanding children’s conceptions of living and animal, Carey (1985) made four assertions: First, children aged four to seven are not able to judge all animals and plants as alive. Carey’s series of studies showed that young children are largely ignorant of the idea that plants are living things and often judge non-living things as being alive. Second, six-year-olds did not understand that living things share similar characteristics. Third, children younger than 10 years of age classified animals and plants as two separate ontological categories and did not recognise the superordinate category of living. In fact, Carey claimed that these children continued to be ignorant of the life-status of plants. And fourth, only by the age of 10 did children display adult patterns of responses. At this age, the majority of children in Carey’s study judged animals and plants to be alive and to share biological properties such as growth. In terms of animal functions, Carey claimed that 10-year-olds see animals as ‘biological beings’ compared with the ‘behaving beings’ seen by younger children. Nonetheless, Carey does not imply that the 10-year-olds are already experts in biology. What Carey tried to describe was the kind of conceptual reorganization children experience during these years. She claimed that the conceptual change involved in the transformation of knowledge between the four-year-old and the 10-year-old about the concept of living is at least as radical as the conceptual reorganization adults’ experience.

Unlike Carey (1985), Bell and Freyberg (1985) found that children as young as five have a relatively simple classification system where living things consist of plants and animals. Nevertheless, as the children grow older, from nine to 15 years, many tended to define animals as large (bigger than insects), found on land either on a farm, zoo or home, with four legs and fur and producing noise. In terms of how children define animals, Trowbridge and Mintzes (1988) also found that students did not include small animals as animals.

A cross analysis of Carey’s (1985) and Bell and Freyberg’s (1985) conclusions about young children’s ideas provided some interesting contrasts. It seems that
Carey viewed the children's ideas as conceptual development characterized by the restructuring of concepts. Conversely, Bell and Freyberg viewed the development of children's ideas on living more as a development of language. In the light of this finding, it is essential to clarify the importance of language in describing or explaining scientific ideas.

3.3 The Importance of Language for Conceptual Understanding

Tytler (2000) gives an account of how children describe their thinking based on a range of perceptual and anecdotal associations. When scientific phenomena are less familiar to children, Tytler claims the use of associative thinking becomes more prevalent. Associative thinking refers to explanations which do not involve a clear statement about the physical change that is occurring. For example, when children observe water boiling they often state, 'air is in the bubbles'. This statement does not give a clear indication of how the child is thinking about the physical change from liquid to gas. Younger children may have experience of these phenomena, but it does not mean that they are able to make sense out of them. This is because they have either attended to these phenomena in different ways or they are unable to make links between them. In other words, the ability of children to explain may largely be attributed to context and accessibility in choosing words. Thus, Tytler (2000) argues that Bar and Travis (1991) seem to underestimate the subtlety of the ways in which language can be used. For example, Bar and Travis and Bar and Galili (1994) tend to assume that the term 'disappeared' used by children when discussing the evaporation of water, is the same as how adults understand it.

According to Bell and Freyberg (1985), as learning takes place, children may construct meaning that is either similar to that intended by the teacher or not. In the process of constructing the intended meaning, the children either ignore teacher-talk or make noises which sound scientific. The teachers, on the other hand, may ignore children-talk. Both teachers and children may, at times, be unaware of particular words which are not understood by either party. Finally, communication difficulties may develop from the peculiarities of the words themselves. Some words may have a range of meanings which may be appropriate for some occasions but misleading in other contexts or situations. Bell's (1981) and Bell and Freyberg's (1985) findings
illustrate the problems for teaching associated with teachers and pupils having different meanings for common language terms. These findings are supported by research by Trowbridge and Mintzel (1988) who suggest that students of all ages have a wide range of conceptions on animal classification both scientifically acceptable and alternative. The alternative conceptions were often found to persist unchanged into adulthood.

In another study conducted in South Africa, Tema (1989) demonstrated that middle and high schools’ students in rural and urban areas hold alternative conceptions of the biological concept ‘animal’. The findings of this study suggest that the pupils had a broader view of the concept of animal compared with studies in other countries because they were able to distinguish animals from plants using the criteria of movement, habitat, external appearance and body functions. These results differ from Bell’s, in that all the children seemed to recognize insects, worms and reptiles as animals using such criteria. This result is particularly relevant to this study because the children in this South African study were bilingual children whose language of instruction in school was different from their home language. Likewise, Villalbi and Lucas (1991) found that the confusion between everyday and ‘scientific’ meanings of the term ‘animal’ did not occur in Barcelona. The children in this study, aged 9, 12 and 15, seemed to include insects and birds as animals. In addition, the majority of the children classified correctly all examples of animals. Like the children in Tema’s (1989) study, they were not responding in English, but in Catalan.

The results from these studies demonstrate that language may have a critical influence on the development of students’ understanding of the concept of living and the subsidiary concepts of animal and plant. In particular, it has been noted that in at least two studies (Tema, 1989; Villalbi & Lucas, 1991) students had a more scientific concept of living at an earlier age when interviewed in their indigenous language compared with students who were interviewed in English in English speaking countries. It may be that there are aspects of the English language that problematise the learning of this and related scientific concepts.
3.3.1 Conceptual development and language

Tytler and Peterson (2000b) claim that children generally move towards a more sophisticated view of the evaporation phenomena with increasing age, but the pathway is complex and determined at different points by exposure to ideas about air, the water cycle, the nature of science knowledge, and by their own growing conceptions of themselves as learners. In their study, they found that children often used associations and narrative links to explain phenomena. These narrative elements may contain personal involvement, social commitments and concerns or recognizable aspects of the children’s identities. As a result of the different ways in which children approach science learning, the boundaries between development and learning seemed to be blurred. Tytler (2000) further elaborates on the difference between Year 1 and Year 6 children in explaining condensation and evaporation and how this can be attributed to, aside from their own ideas on the water cycle image, the children’s options for using words.

Tytler (2000) found that older children display a surer sense of ontological categories, greater epistemological sophistication, greater precision in language use, and a greater range of associations. Tytler explained that older children have much greater access to the phenomenological language commonly used in relation to evaporation and condensation. In terms of conceptual or ontological dimensions, Tytler claims Year 6 students (10 – 11 years) have a greater precision in distinguishing between fundamental ontological categories such as matter, events and abstract entities and a greater domain specific knowledge that provides access to subsidiary concepts. Epistemologically, Year 6 students display a surer understanding of the evidence they use to justify their explanations, they are better able to link their ideas, develop their observation skills in support of better interpretations, and use conceptual language appropriately. In addition, Year 6 students are exposed to rich personal episodes that enable them to make better sense of the phenomena. Logically, these are the factors that Tytler proposed as dimensions of child development that would improve understanding of the conceptions of evaporation and condensation.
3.3.2 Conceptual development and second language

Tytler and Peterson (2000b) have shown that narratives are part of children’s understandings of phenomena and a fundamental aspect of knowing. Simultaneously, children are influenced by these narratives when they provide explanations to scientific phenomena. As a result, when asked to explain a phenomenon in a second language, a child who has limited second language acquisition will tend to simply provide explanations using familiar words which may not necessarily be appropriate, or may not convey the intended meaning. Hence, a change in the language of instruction would seem an additional complication when children’s understanding of scientific concepts is already uncertain.

Evidence presented in the literature suggests that the element of language is a fundamental medium through which all aspects of conceptual development are mediated. The act of introducing a new concept cannot be initiated without the support of language. Another important implication from the discussion above is the notion of children’s alternative conceptions or misconceptions. It has been argued that alternative conceptions are based on naive theories and conceptual change is said to occur only when there are changes that occur to the naive theory (Vosniadou, 1994; 2002). Driver and Oldham (1986) assert that children develop their ideas and beliefs about the natural world by actively making connections between aspects of any kind of situation and the children’s prior knowledge. It is in this regard that Vygotsky’s work is particularly relevant to this study. Vygotsky (1986), in a similar vein to driver and Oldham, argued that everything is learned through interaction and integration with an individual’s existing mental structure. For Vygotsky, social interaction plays a fundamental role in the development of cognition. The work of Vygotsky has challenged the notion that the development and construction of children’s ideas to form a bigger body of knowledge can occur in isolation.

Vygotsky (1986) devised the notion of the ‘Zone of Proximal Development’ to summarize the potential for cognitive development. This ‘zone’ is the limited area of exploration for which an individual is cognitively prepared. Unless there is social and interactive communication taking place, this ‘zone’ will never be fully developed. In this sense, Vygotsky, suggested that thought development is
determined by language because it is through language that new data can be labelled and used for interaction (Boudourides, 1998, Briner, 1999).

Vygotsky (1986) claimed that 'the difficulty with scientific concepts lies in their verbalism' (p. 148). He emphasized that in the case of scientific thinking, the initial verbal definition is of critical importance (p. 148). According to Vygotsky, word development is associated with conceptual development and involves the move from 'everyday' to 'schooled', or 'scientific' concepts (Wertsch, 1990). Everyday concepts are closely tied with the word or name of the object or condition under consideration. Conversely, scientific concepts are systematic, considered independently from the immediate image created by the word and can be manipulated in the mind (Gallimore & Tharp, 1990).

In order to explore conceptual development in children, the Vygotskian notion of 'everyday' and 'schooled' or 'scientific' is particularly useful. In Brunei, however, this framework is complicated because the everyday words are in Malay and the 'schooled' or 'scientific' words are in English. This situation creates a further barrier to what Vygotsky explains as evolutionary development in word meaning (Gallimore & Tharp, 1990). The answer to the question: "What happens in the mind of the child to the scientific concepts he is taught at school?" (Vygotsky, 1986, p. 149) becomes even more complex due to the bilingual system of education.

3.3.3 Vygotsky’s framework- Language and constructivism

Of central importance in this study is the difference between children's conceptual development when learning a formally taught science concept (the concept of living) and concepts that are not taught formally (the concepts of evaporation and condensation). To attempt to trace and analyse this difference, Vygotsky's (1986) distinction between spontaneous learning and formal school instruction is used as an interpretive framework.

Vygotsky's writing on scientific concepts constitutes a central theme in his rather complex theory. Vygotsky saw the development of 'scientific' concepts as fundamentally different from 'everyday' or 'spontaneous' concepts, "both in their defining characteristics and in their manner of acquisition" (Wells, 1994, p. iii).
Wells (1994) asserts that according to Vygotsky, scientific concepts are acquired "as a result of deliberate and systematic instruction in an educational setting" (p. v) while everyday or spontaneous concepts are acquired "through the social interaction that occurs in the course of engagement in jointly undertaken activities in his or her immediate community" (p. v).

In the development of scientific concepts, Vygotsky (1986) outlined a set of general principles that occur during formal instruction (Panofsky, John-Steiner & Blackwell, 1990). First, he believed that children are in the position of consciously regarding and manipulating the object of instruction. Second, the modality of school instruction is verbal instruction. Learning thus proceeds as children are able to define a term in a logical and conceptual way. Wells (1994) further claimed that Vygotsky's scientific concepts centred around four features: generality, systematic organization, conscious awareness and voluntary control. Wells (1994) asserts that it is the first two features that make the scientific concepts very different from the everyday concepts. As Wells (1994) explains; "everyday concepts are related to the world of experience in a direct but relatively ad hoc manner, scientific concepts are both more abstract and more general; their primary relationship is to other concepts within the relevant system and only indirectly to the particular objects and events that they subsume" (p. iii). According to Vygotsky (1986), "school instruction induces the generalizing kind of perception and thus plays a decisive role in making the child conscious of his own mental processes" (p. 171). Vygotsky (1986) emphasized that "instruction is one of the principal sources of the schoolchild's concepts and is also a powerful force in directing their evolution; it determines the fate of his total mental development" (p. 157).

From a Vygotskian (1986) perspective, the process of conceptual development is mediated by language. The development of cognition will, therefore, be impeded as a result of language constraints. Unless there is social and interactive communication taking place, the limited mental structure of an individual will never be fully developed. Instructional interaction is an important aspect of communication and is considered in more detail in the following section.
3.3.4 Instructional interaction

Research has identified many aspects of instructional interaction. Tello (2002) defined instructional interaction as "directed communication regarding course content and topics between the instructor and student or among students in the online course" (p. 13). This study is concerned with aspects of instructional interaction in a classroom and Tello's definition is appropriate for this purpose.

The literature discusses many aspects of the development of children's verbal communication as a result of instructional interaction in classrooms. For example, good questioning techniques are an essential aspect of a teacher's pedagogy for developing pupil's understanding (Allerton, 1992; Camp, 1993). Bruner (1996) has long seen children as an imitative learner. His theory describes how children as the novice can learn how to do x by being shown by the teacher as the expert. Through repeated practice, the expert will transmit a skill x to the novice, who in return, has to model the act in order to succeed. Piaget (Bybee & Sund, 1982) and Vygotsky (1986) concur that children are capable of imitating and deferring imitation at certain stages of cognitive development. The significance of this is that in the process of learning, not only do children acquire new knowledge, they may be inclined to imitate the teachers' behaviour.

Rodrigues and Thompson (2001) claim that it is classroom dialogue that enables students to engage with meaningful scientific language, even when the materials and themes of topics are familiar to students. Bruner (1996) revealed that most teachers' questions to pupils are those that can be answered in a few words or even by 'yes' or 'no'. Horwood (1988) further claimed that in ordinary science teaching practice and in science texts, the terms 'describe' and 'explain' are used in variable, inconsistent and confusing ways.

Parents in Brunei send their children to school as early as two and a half years of age. Oldfather et al. (1999) asserted that the culture of a family influences the child's use and understanding of language. According to Oldfather, some families in this study asked questions of their children for which they knew the answers simply as a means of 'instructing' or teaching their children about the world. Others asked their children questions only to elicit information that they, the parents, did not already
have. Consequently, there are two groups of children coming to school; first, those who will ‘speak up’ when they are asked questions, and second, those who will ‘talk’ only when they think it is appropriate. The second group of children have constructed a different understanding of the intentions behind the questions. Consequently, four undesirable effects may snowball in a community: first, children may start to develop incompetent communication skills, second, their way of communicating and explaining may later be accepted and become part of the culture, third, individuals from this community may later become teachers, and finally, the pattern of communication may be passed from the teacher to the new young generation.

The pertinent point from this discussion for this study is that the influence of culture may have adverse effects on the nature of teacher-pupil interactions in school. In Brunei culture, children are not used to offering their views in a classroom setting. Moreover, it is possible that teachers are not asking questions in the most appropriate way. A cartoon illustration by Cuboi (Borneo Bulletin, September 10, 2001) portrays an interesting juxtaposition of popular youth culture in Brunei and the more traditional classroom culture. The cartoon succinctly demonstrates that language is a crucial factor in determining active interaction between teachers and pupils and the difficulty of this active interaction in Brunei (Figure 3.1).

The cartoon (Figure 3.1) was published in the wake of ‘concert craze’ in Brunei in 2001. It highlighted an important facet of student behaviour that students are quiet in the classrooms despite the fact that they are actually vociferous outside the school premises. Furthermore, the cartoon creates an image of a teacher who does not have sufficient command of English. The nature of the cartoon raises several questions about the school culture in Brunei. What hinders the students from having active communication? Why does the teacher not have sufficient command of English? As a result of the teacher’s limited proficiency in English, what would be the outcomes in terms of students’ learning?
Figure 3.1 A cartoon illustrates a probable occurrence in Brunei classrooms (Borneo Bulletin, September 10, 2001).

The theory of conceptual change has been found by researchers to be a fruitful framework for explaining and analysing science understanding and learning. In the following sections, literature related to conceptual change is reviewed. The final section of this chapter draws on this literature to develop the theoretical framework that provides a lens through which the data presented in this study are viewed.

3.4 A Theoretical Background

3.4.1 Learning as conceptual change

Before conceptual change is considered, it is necessary to define a concept. Philosophers and psychologists have proposed different views of the nature of concepts. According to White (1994), concepts include “all knowledge that a person has, and associates with, the concept’s name” (p. 118). Carey (2000) explains that ‘concepts’ are units of mental representation roughly equivalent to a single word, such as 'animal' and 'heat'. Carey’s definition resembles Thagard’s (1992) notion of ‘concepts’, that is, sets of synonyms or related ideas (Carey, 2000; Thagard, 1992). Carey, however, described ‘individual concepts’ as complex representational structures whereas Thagard (1992) saw concepts as complex computational
structures organized into kind-hierarchies and part-hierarchies. Thagard (1992) proposed that concepts should not be viewed in isolation, rather, concepts fit together into conceptual systems. He explained that a conceptual system can be analyzed as a network of nodes, with each node corresponding to a concept, and each line in the network corresponding to a link between concepts. For the purpose of this study, the definition of ‘concept’ is constructed from both Thagard and Carey’s definitions as a set of synonyms or related ideas that fit into a conceptual system.

Many recent analyses of theory change in the history of science have focused on the notion of conceptual change (e.g. Kuhn, 1962; Thagard, 1992). Conceptual change has been defined as changes in scientific theories that occur when new concepts are proposed and old concepts must be radically changed or replaced to accommodate the new concepts (Dunbar, 1997). This notion of conceptual change, at the scientific theory level, has been used as an analogue to describe students’ learning of scientific concepts.

The most well-known conceptual change theory in science education was proposed by Posner, Strike, Hewson and Gertzog (1982). Posner et al. (1982) believed that learning is best viewed as a process of conceptual change. Thagard (1992) proposed an analogy to describe the magnitude of conceptual change. He said that conceptual change is more than just changing beliefs, like replacing or changing the parts of a bicycle; in fact, the change is more fundamental, like changing a bicycle frame. According to Thagard, if someone wants to change the frame of a bicycle, he must already have a bicycle that no longer suits his needs. What Thagard means is that conceptual change involves rejection of previously held beliefs. Consequently, conceptual change theory presupposes that one already has some ideas of what a particular to-be-learned concept is. A considerable number of studies have supported this. For example, Henriques (2000) believed that children have their own understanding of many scientific concepts prior to receiving formal science instruction. Carey (2000) emphasized the importance of identifying children’s initial understanding of content knowledge, or children’s alternative conceptual frameworks to bring about conceptual change and Chi, Slotta and deLeeuw (1994) summarized conceptual change as learning that changes some existing conception.
Learning from a conceptual change perspective is thus understood as the result of the interaction between what a student is taught and his or her existing ideas or concepts.

3.4.2 Perspectives of conceptual change

The dynamic processes of conceptual change are seen in the research literature from different perspectives that are described and elaborated in the following sections. First, an epistemological perspective, second, a social/affective perspective and third, an ontological perspective of conceptual change are considered before an argument for the use of multiple theoretical perspectives in research is presented.

3.4.2.1 An epistemological perspective

According to Cohen, Manion and Morrison (2000), epistemology concerns the ‘very bases of knowledge – its nature and forms, how it can be acquired, and communicated to other human beings” (p. 6). The focus of Posner et al.’s (1982) conceptual change theory is from an epistemological perspective. This model generally relies on the conditions whereby existing schema are modified by new knowledge and is similar to, but less global and formal, than Piagetian descriptions of assimilation and accommodation (Bybee & Sund, 1982).

Posner et al.’s model (1982) can be considered an epistemological model because it outlined four conditions to be met for conceptual change to occur, thus focusing on how knowledge can be acquired. First, Posner et al. suggested that there must be dissatisfaction with existing conceptions. The authors claimed that the more students seriously consider inconsistencies, the more dissatisfied they become with their current concepts, and ultimately, the more likely they will become receptive to the accommodation of new ideas.

Second, Posner et al. explained that a new conception must be intelligible. This means that the learner should be able to find a way of representing the new scientific conceptions. Third, a new conception must appear plausible, so the learner consistently believes the conception to be true. Finally, a new concept should be fruitful. The learner should be able to make connections with other conceptions and
transfer the idea to a new situation (Hewson, 1981, 1982, 1996; Hewson & Hewson, 1992; Posner et al., 1982).

Posner's model was later researched extensively by Hewson and colleagues (1992). Hewson described learning as a process which involves an interaction between new and existing conceptions with the outcome being dependent on the nature of the interaction. If the new conceptions are intelligible, plausible and fruitful to the learner, then conceptual change learning is said to have taken place by the process of "conceptual capture" (Hewson, 1981, p. 386). This process is described by Posner et al. as "accommodation" (Posner et al., 1982, p. 214). The extent to which the conception meets the three conditions is described by Hewson and Hewson as being the "status" of a person's conception (p. 60).

3.4.2.2 A social/affective perspective

Pintrich, Marx and Boyle (1993) described the epistemologically-based learning theories as 'cold' and criticized Posner's model of conceptual change as overly rational and focusing only on student cognition without considering the ways in which students' motivational beliefs about themselves as learners and the roles of individuals in a classroom influence learning. Pintrich et al. (1993) and Pintrich (1999) assert that conceptual change is influenced by personal, motivational, social and historical factors. These authors described four motivational constructs including goals, values, self-efficacy and control beliefs, as potential mediators of learning.

A social/affective perspective supports the assumption that "classroom context influences the nature of students' cognitive processing and potential for conceptual change" (Pintrich et al., 1993, p. 178). Pintrich et al. contended that "the conceptual change process may be influenced by being situated within different classroom contexts and shaped dramatically by the nature of the interactions between students and the teacher" (p. 172) and "an individual student's goal for knowledge, learning, and for classroom life in general may have a significant impact on the conceptual change process" (p. 173). Pintrich et al.'s (1993) and Pintrich's (1999) ideas about conceptual change resonate with earlier work from Vygotsky (1986) who examined education from a socio-cultural perspective.
Vygotsky (1986) claimed that everything is learned through interactions with others and then integrated into the individual's mental structure. Vygotsky explained that social interaction helps to maximize the 'zone of proximal development' (p. 187) or the potential time span for cognitive development. The implication for instruction from Vygotsky's theory is that children need to be immersed in a socially rich environment to help them develop a higher level of cognitive functioning. According to Vygotsky, when a child learns new concepts in school, the development of those new concepts has only just begun. The activity of school instruction actually precedes what could be achieved in terms of cognitive development without the social milieu of the school environment.

3.4.2.3 An ontological perspective

Conceptual change learning also can be viewed from an ontological perspective (Chi, 1992; Chi & Roscoe, 2002; Chi, Slotta, & deLeeuw, 1994). From this perspective, Chi (1992) explains, "ontology divides our knowledge into categories that are conceptually distinct in a way that is somewhat difficult to define, although the distinction can be easily captured" (p. 130). The basis for Chi's model is the assumption that all concepts belong to an ontological category. Chi described a few major categories in the world that are ontologically distinct physically, and should be perceived by adults as ontologically distinct psychologically. She proposed three basic ontologically distinct categories to which physical entities of the world belong. These ontological categories are (1) matter (or material substances or things), (2) events and (3) abstractions. The categories are based on people's epistemological supposition of the nature of conceptions about the entities of the world. There is a hierarchy of subcategories branching out from each of these main categories or trees.

Categories within each tree differ ontologically from the other trees because they do not share any ontological attributes. For example, the category of 'living' in the main category of matter is ontologically different from 'the procedure' in the main category of events (Chi, 1992). The category in the main category of matter, on the other hand, may have defining attributes. For example, the category of 'living' may branch out to 'animals' and 'plants'. However, the ontological attributes of
'animals' cannot be used sensibly to modify the ontological attributes of 'plants'. As a result, the categories of 'animals' and 'plants', even though they are situated in the main category of matter, can also be described as ontologically distinct. Chi, therefore, claimed that based on these ontological distinctions, two kinds of conceptual change are possible; within and across the ontological categories. An example of conceptual change within the ontological category is when the concept of 'animals' migrates up to merge with 'living things'. Similarly, when the concept of 'living things' migrates down to define the attributes of 'plants', conceptual change within an ontological category is said to happen. 'Plants', however, cannot become a part of 'animals' because 'animals' and 'plants' are two distinct groups of living things and do not share ontological attributes such as 'social behaviour' and 'having specific excretory structures'. While social behaviour is present among animals, plants do not have this characteristic. As the differences are realised, Chi claimed that conceptual change across ontological categories is occurring.

3.4.2.4 Multiple perspectives of conceptual change

Since Posner et al. (1982) proposed the conceptual change model, researchers have been advancing the model beyond the epistemological dimension. Pintrich et al.'s (1993) model on the social/affective dimension has, however, been largely ignored by researchers in science education. Tyson, Harrison, Venville and Treagust (1997) proposed a multi-dimensional model that incorporates the epistemological, social/affective and ontological perspectives for interpreting classroom conceptual learning of science. This multi-dimensional approach appeared to fill the void created by the divergent research perspectives of Posner et al. (1982) and Pintrich et al. (1993). Tyson et al. assert that to create an holistic picture of conceptual change, it is necessary to be able to consider interpreting a learning situation from different theoretical perspectives. This model has been shown to be a robust framework for interpreting conceptual learning in a number of recent case studies (e.g. Harrison & Treagust, 2001; Venville & Treagust, 1998). The power of multiple theoretical perspectives of conceptual change for examining learning in science that is evident from these studies was applied to the construction of a theoretical framework for this research.
3.4.3 Using conceptual change theory in this study

Thagard (1992) offered a premise which says, "Understanding the growth of scientific knowledge requires a theory of conceptual change" (p. 246). Yet, researchers have proposed different views on defining conceptual change. In fact, there is some controversy as to whether there is a definite representational system that accurately describes conceptual change.

To describe, to determine and identify conceptual change is becoming more complicated. Yet, a conceptual change theoretical framework was chosen for this study because a rich account of conceptual change can contribute to explanations of the development of children’s understanding and learning of science. Venville and Treagust (1998) assert that conceptual change is a research agenda which evolved rapidly from the alternative conceptions movement during the 1980s. Conceptual change is not a learning theory but a product of constructivist epistemology where knowledge acquisition involves actively generating and testing alternative propositions (Tyson et al., 1996). In an attempt to produce an effective framework in which to embed the issues presented in this study, several conceptual change perspectives have been examined in the preceding literature review. Two of these perspectives of conceptual change, an ontological perspective and an epistemological perspective, are construed as the basis of a theoretical framework for answering the research questions in this study.

The science topics relevant to this study, evaporation and condensation and living and non-living things, are challenging in an ontological sense for young children to comprehend. Therefore, one aspect of the theoretical framework will focus on conceptual change as ontological change. Carey (1985), Thagard (1992) and Chi (1992) have explored the evidence of conceptual change that occurs within and between ontological categories.

While Carey’s (1985) studies concentrated on children’s acquisition of new theories in biology, Chi (1992) examined children’s conceptual development in physics. Since two independent science disciplines have been chosen as the context of this research, two different conceptual change models have been selected as interpretive frameworks. Children’s conceptual development when learning evaporation and
condensation is examined from the perspective of Chi’s ontological conceptual change model. Carey’s ontologically-based conceptual change model, on the other hand, is used to examine the development of conceptual understanding about living.

Venville and Treagust (1998) claimed that they found it difficult to separate the ontological and epistemological aspects of learning in their study. They further acknowledged that there is an overlap and interaction between the two perspectives. Tyson et al. (1997) also warned that to create a holistic picture of conceptual change, it is necessary to be able to consider interpreting a learning situation from different theoretical perspectives. The epistemological conceptual change model developed by Posner et al. (1982) and researched extensively by Hewson and Hewson (1992) is therefore also employed. Hewson and Hewson (1992) describes learning as “a process in which a person changes his or her conceptions by capturing new conceptions or exchanging existing conceptions for new conceptions, i.e., a process of conceptual change” (p. 59). This conceptual change model describes how learners use their existing knowledge to determine whether a new concept is intelligible, plausible and fruitful (Figure 3.2). The status of a learner’s conception is thus determined by the extent to which the learner knows what the new concept means, whether or not the learner believes that it is true and the ability of the learner to solve previously unsolved problems. It follows that the more conditions that a conception meets, the higher is its status. In this study, children’s understanding of evaporation and condensation are further analyzed from this epistemological perspective of conceptual change.

3.5 Theoretical Framework

The extensive literature presented earlier in this chapter has been synthesized and integrated to construct a comprehensive theoretical framework that will provide a basis for answering the research question. There are several aspects of the theoretical framework that form a branching model that is presented in Figure 3.3. The primary rationale of this study was to provide explanations for the undesirable performance of Brunei children in science. Consequently, one of the most important aspects of the theoretical framework is research pertaining to students’ understanding of the two clusters of science concepts chosen as the focus of this study, evaporation and
condensation and living and non-living things. This aspect of the theoretical framework is presented at the top of Figure 3.3 because of the central nature of students' understanding of science to this research. A further important rationale for this study was to investigate the influence of Brunei’s bilingual education policy on students' understanding of science. As discussed previously, all science learning is mediated through language, therefore 'language' is the second aspect of the theoretical framework that sits directly under 'science concepts' in Figure 3.3. The structure of the model was constructed to highlight the relationship between the understanding of science concepts and the languages of particular relevance to this study, Malay and English.

<table>
<thead>
<tr>
<th>Intelligible</th>
<th>Is the conception intelligible to the learner? The concept is intelligible to the learner if the learner is able to find a way of representing the scientific conceptions of the concepts of evaporation and condensation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plausible</td>
<td>Is the conception plausible to the learner? The concept is plausible to the learner if the conceptions are intelligible and the learner consistently believes the conceptions to be true.</td>
</tr>
<tr>
<td>Fruitful</td>
<td>Is the conception fruitful to the learner? The concept is fruitful to the learner if the conceptions are intelligible, plausible and the learner is able to make connections with other conceptions and transfer the idea to a new situation.</td>
</tr>
</tbody>
</table>

*Figure 3.2* The conditions that have to be met for conceptual change to occur (adapted from Hewson and Hewson, 1992).
The paradigm in which this research is situated is defined by the theory of knowledge called constructivism. At the next level within the theoretical framework of this study the model divides into two, with the aim of each branch representing different ways of examining learning within the constructivist paradigm. The first branch represents conceptual development and the second branch represents conceptual change. Both conceptual development and conceptual change form aspects of this theoretical framework through which student learning of science concepts are viewed and analysed. At another level, the conceptual change branch is once again divided into two, an epistemological and an ontological perspective of conceptual change (Figure 3.3). Each of these perspectives, again, is used to analyse and understand student learning in different ways.

*Figure 3.3* The theoretical framework that guides this study.
In sum, the theoretical framework of this research is situated within the paradigm of constructivism. The five critical aspects of the framework are 1) the clusters of science concepts including evaporation and condensation and living and non-living things, 2) language, in particular the Malay and English languages, 3) conceptual development, and 4) an ontological and 5) an epistemological perspective of conceptual change. The broad relationships of the five aspects of the theoretical framework are represented in the model presented in Figure 3.3.

A more detailed overview of how each of the aspects of the theoretical framework was used to address the research questions is presented in Table 3.1. This table also outlines the theorisers who were most influential for informing the various aspects of the theoretical framework.

3.6 Summary

The literature review presented in Chapter 2 and in this chapter has provided substantial information on the conditions necessary for high-quality science learning experiences for children. As the information presented in this chapter has unfolded, insights into the dilemmas and mediating constraints that Brunei children may encounter as a result of the bilingual system of education were realised. This insight through the literature, nevertheless, strengthens the need to investigate what really happens when children learn science in Brunei.

The literature review has taken the reader, and indeed the author, on a journey through the history of bilingualism in Brunei and other countries to the cultural context in which it currently exists. Aspects of language and evidence of conceptual understanding in learning science from previous research was then reviewed.

The theoretical framework developed for this study is an important, useful innovation that enabled the researcher to analyse patterns of conceptual development about science concepts in a broad spectrum of Brunei pupils. This study, being the first of its kind in this country, has provided a framework that will form a basis on which more local research can be conducted. The next chapter presents the research methodology that was guided by the theoretical framework presented in this chapter. It highlights the justifications for the selection of methods and techniques used for
gathering data. It also explains, in detail, the process used for interpreting and analysing data.

Table 3.1 *Summary of aspects of theoretical framework used to address each of the research questions.*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Chapter</th>
<th>Aspect of Theoretical Framework</th>
<th>Predominant Theorisers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>6</td>
<td>Science concepts and conceptual change</td>
<td>Bar (1989); Bar &amp; Galili (1994); Bar &amp; Travis (1991); Tytler (2000);</td>
</tr>
<tr>
<td>1b</td>
<td>6</td>
<td>Conceptual development</td>
<td>Tytler (2000); Vygotsky (1986)</td>
</tr>
<tr>
<td>1c</td>
<td>6</td>
<td>Conceptual development: the issues of language and gender</td>
<td>Clark &amp; Trafford (1996); Nyland (2001); Wright (1999)</td>
</tr>
<tr>
<td>1d</td>
<td>7</td>
<td>Ontological perspective of conceptual change</td>
<td>Chi (1992); Russell &amp; Watt (1990); Russell, Harlen &amp; Watt (1989)</td>
</tr>
<tr>
<td>1e</td>
<td>7</td>
<td>Epistemological perspective of conceptual change</td>
<td>Hewson &amp; Hewson (1992); Hewson &amp; Thorley (1989); Posner, Strike, Hewson &amp; Gertzog (1982)</td>
</tr>
<tr>
<td>2a</td>
<td>8</td>
<td>Science concepts and conceptual change</td>
<td>Carey (1985); Bell (1981); Bell &amp; Freyberg (1985); Venville (2004)</td>
</tr>
<tr>
<td>2b</td>
<td>8</td>
<td>Conceptual development</td>
<td>Carey (1985); Bell (1981); Bell &amp; Freyberg (1985); Venville (2004); Vygotsky (1986)</td>
</tr>
<tr>
<td>2c</td>
<td>8</td>
<td>Conceptual development: the issues of language and gender</td>
<td>Clark &amp; Trafford (1996); Nyland (2001); Wright (1999)</td>
</tr>
<tr>
<td>2d</td>
<td>9</td>
<td>Ontological perspective of conceptual change</td>
<td>Carey (1981)</td>
</tr>
</tbody>
</table>
CHAPTER FOUR

RESEARCH METHODOLOGY

4.0 Introduction

This chapter presents the research design and methodology of this study. The planning of the methodology was guided by the research questions and the theoretical framework presented in the previous chapter. The initial part of this chapter provides in tabular form a broad overview of the relationship between the research questions and the methodology. Subsequently, each of the aspects of the methodology is more fully explained in the following chapter sections.

4.1 Research Questions and Methodology

The relationship between research questions and methodology is a critical aspect of well-planned research. Table 4.1 is a detailed matrix that presents the research questions from this study and the data source, instrument, data collection strategy and analysis that were used to answer each research question. This table is included here to demonstrate the carefully planned approach designed to answer each of the research questions. Moreover, the matrix provides an overview that can be referred to at any time in order to gain a clear understanding of the relationship between the research questions and the various aspects of the research discussed in detail in this chapter.

4.2 Research Approach

Table 4.2 provides an overview of the methodological research approach taken for this study. This table also can be used as an advanced organizer for the remaining of this chapter. While the research paradigm and theoretical framework were explored in the previous chapter, this chapter will proceed through a discussion of the research design, data collection, data interpretation, research rigour and ethical issues.
Table 4.1 Research methodology matrix.

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data source and sample</th>
<th>Data type</th>
<th>Instrument developed</th>
<th>Data collection strategy</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. What are Brunei children’s naive conceptions about evaporation and condensation?</td>
<td>School A 180 children Primary 1, 3 and 4 and 18 children (from the main sample)</td>
<td>Qualitative and quantitative</td>
<td>Semi-structured interview questions and anecdotal evidence</td>
<td>180 children were interviewed in groups of 3 18 children were interviewed in detail individually</td>
<td>Descriptive, categorization, anecdotal evidence, statistical significance and graphical presentations</td>
</tr>
<tr>
<td>1b. Is there any indication of a pattern of development of understanding of the concepts of evaporation and condensation from Primary 1 – 4? What impact does language transition have on this pattern of development?</td>
<td>School A 180 children Primary 1, 3 and 4</td>
<td>Quantitative Forced-response interview questions</td>
<td>Group interviews (3 in a group)</td>
<td>Frequencies, statistical significance and graphical presentation</td>
<td></td>
</tr>
<tr>
<td>1c. Do boys’ and girls’ conceptions of evaporation and condensation progress in the same way?</td>
<td>School A 110 males 70 females Primary 1, 3 and 4</td>
<td>Qualitative and quantitative Semi-structured and forced-response interview questions and anecdotal evidence</td>
<td>Group interviews (3 in a group)</td>
<td>Frequencies, statistical significance and graphical presentation</td>
<td></td>
</tr>
<tr>
<td>1d. What are the ontological differences in the way that children understand the concepts of evaporation and condensation from the primary levels 1 – 4?</td>
<td>School A 180 children Primary 1, 3 and 4</td>
<td>Qualitative and descriptive Semi-structured interview questions</td>
<td>Group interviews (3 in a group)</td>
<td>Anecdotal, coding and descriptive statistics</td>
<td></td>
</tr>
<tr>
<td>Research questions</td>
<td>Data source and sample</td>
<td>Data type</td>
<td>Instrument developed</td>
<td>Data collection strategy</td>
<td>Data analysis</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>--------------------------</td>
<td>-------------------------------------</td>
<td>--------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>1e. What is the status of the children’s conceptions of evaporation and condensation from Primary 1 – 4?</td>
<td>School A</td>
<td>Qualitative and descriptive</td>
<td>Detailed interviews on one of two scenarios</td>
<td>One-to-one interviews</td>
<td>Descriptive, anecdotal evidence and categorizing the status</td>
</tr>
<tr>
<td></td>
<td>18 children Primary 3, 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a. What are Brunei children’s naïve conceptions about living and non-living things?</td>
<td>School B</td>
<td>Qualitative</td>
<td>Semi-structured interview questions</td>
<td>One-to-one interview</td>
<td>Descriptive and categorization</td>
</tr>
<tr>
<td></td>
<td>75 children Primary 1, 3, 4, 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2b. Is there any indication of a pattern of development of understanding of the concepts of living and non-living things from Primary 1 – 6? What impact does language transition have on this pattern of development?</td>
<td>School B</td>
<td>Quantitative</td>
<td>Forced-response interview questions</td>
<td>One-to-one interview</td>
<td>Frequencies, statistical significance and graphical presentation</td>
</tr>
<tr>
<td></td>
<td>75 children Primary 1, 3, 4, 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2c. Do boys’ and girls’ conceptions of living and non-living things progress in the same way?</td>
<td>School B</td>
<td>Qualitative and quantitative</td>
<td>Semi-structured and forced-response interview questions and anecdotal evidence</td>
<td>One-to-one interview</td>
<td>Frequencies, statistical significance and graphical presentation</td>
</tr>
<tr>
<td></td>
<td>38 males 37 females Primary 1, 3, 4, 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2d. What are the ontological differences in the way that children understand the concepts of living and non-living things across the primary levels 1 – 6?</td>
<td>School B</td>
<td>Qualitative and descriptive</td>
<td>Semi-structured interview questions</td>
<td>One-to-one interview</td>
<td>Anecdotal, coding and descriptive statistics</td>
</tr>
<tr>
<td></td>
<td>75 children Primary 1, 3, 4, 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.2 An outline of the research approach.

<table>
<thead>
<tr>
<th>Aspects of the research process</th>
<th>Approach taken in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research paradigm</td>
<td>Constructivism</td>
</tr>
<tr>
<td>Theoretical framework</td>
<td>Learning in a bilingual classroom</td>
</tr>
<tr>
<td></td>
<td>Conceptual development</td>
</tr>
<tr>
<td></td>
<td>Perspectives of conceptual change</td>
</tr>
<tr>
<td></td>
<td>• Epistemological conceptual change</td>
</tr>
<tr>
<td></td>
<td>• Ontological conceptual change</td>
</tr>
<tr>
<td>Research design</td>
<td>Two cross sectional case studies</td>
</tr>
<tr>
<td>Data collection</td>
<td>Pupil interviews</td>
</tr>
<tr>
<td></td>
<td>Classroom observations</td>
</tr>
<tr>
<td>Data interpretation</td>
<td>Analysis of interviews</td>
</tr>
<tr>
<td></td>
<td>Analysis of field notes</td>
</tr>
<tr>
<td></td>
<td>Classification of categories of conceptions</td>
</tr>
<tr>
<td></td>
<td>Classification of status of conceptions</td>
</tr>
<tr>
<td>Research rigour</td>
<td>Validity</td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
</tr>
<tr>
<td></td>
<td>Credibility</td>
</tr>
<tr>
<td></td>
<td>Transferability</td>
</tr>
<tr>
<td></td>
<td>Dependability and confirmability</td>
</tr>
<tr>
<td>Ethical issues</td>
<td>Access and acceptance</td>
</tr>
<tr>
<td></td>
<td>Informed consent</td>
</tr>
<tr>
<td></td>
<td>Anonymity and confidentiality</td>
</tr>
</tbody>
</table>

4.3 Two Cross Sectional Case Studies as the Research Design

This study sought to identify how Brunei primary school children's conceptual understandings develop as they progress through the primary levels. Several studies have shown that children show a hierarchy of conceptual development when learning about the concepts of evaporation and condensation. Tytler (2000), however, pointed out that these studies of changes in children's conceptions are not
always sensitive to the subtleties of language and reasoning particularly when data is collected through pencil and paper tests. The uniqueness of Brunei’s bilingual system of education motivated the researcher to ensure an in-depth evaluation so that the information obtained would offer insights into the real dynamics of conceptual change and language (Cohen, Manion & Morrison, 2000). As children’s explanations of the science concepts were considered crucial in deciding whether or not the Brunei system of bilingual education has an impact on children’s conceptual development in learning science, case study was used as the research design (Merriam, 1998).

The importance of case study as a research strategy for researchers in education is well documented (Merriam, 1998; Yin, 1994). Yin (1994) defined case study as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p. 13). Yin (1994) asserts that case study research can include both quantitative and qualitative methods. Case studies, however, become particularly useful when “one needs to understand some special people, particular problem, or unique situation in great depth, and where one can identify cases rich in information – rich in the sense that a great deal can be learned from a few exemplars of the phenomenon in question” (Patton, 1990, p. 54). In this regard, qualitative research is often cited as the “umbrella term” (Merriam, 1998, p. 10) for case study because “qualitative evaluations often yield such rich case study data” (Patton, 1990, p. 54). Because this study focuses on evaluating the Brunei bilingual system of education by analyzing the development of children’s conceptual understanding in science not only holistically, but also in depth and detail, a qualitative case study was selected as the most appropriate approach.

Case study research can be designed as both single and multiple case studies (Yin, 1994). This particular study involved collection and analysis of data from two cases. Case Study 1 is about the cluster of concepts associated with evaporation and condensation, and Case Study 2 is about the cluster of concepts associated with living and non-living. One example of research employing multiple case studies is Lederman’s (1999) study about the relationship of teachers’ understanding of the nature of science and classroom practice. Instead of studying one high school
biology teacher, he studied five. He then offered a cross case analysis suggesting other critical factors that may influence classroom practice. Merriam (1998) asserts that the more cases included in a study, the more compelling the interpretation is likely to be. In addition, she reveals that the inclusion of multiple cases enhances external validity of the study. Two case studies were carefully selected in order to observe whether the linguistic conditions produced similar or contradictory results for the two different science concepts investigated in this study. Moreover, the flexibility of this research design gave opportunity for the researcher to modify and improve research strategies in Case Study 2.

This study gathers data from different participants and at different points in time. The participants involved were from Primary levels 1, 3 and 4 (for Case Study 1) and from Primary levels 1, 3, 4, 5 and 6 (for Case Study 2) children. Information from these groups of children was vital in providing a continuous snapshot of the pattern of children's conceptual understanding about the two clusters of science concepts at different primary levels.

The case studies employed two sources of evidence: direct observation and systematic interviewing (Yin, 1994). Case studies are concerned with process and meaning, rather than outcomes, and rely on fieldwork (Merriam, 1988). In fact, one of the strengths of case studies is that they result in data from real contexts that are more readily applicable to other real contexts.

4.4 Qualitative Data Collection Methods

The choice of methods of data collection for this study was influenced by two ideas. First, Hewson and Hewson (1992) assumed that it is necessary to have either verbal or written forms of communication (not actions) in determining the status of a person's conceptions. Second, Bar (1987) showed that the only reliable method of testing young children up to the age of nine is the individual oral interview method. Data were, therefore, collected through qualitative interviews. This qualitative method provided a rich context for exploring children's alternative and scientific conceptions about the clusters of concepts of evaporation and condensation, and living and non-living. It also permitted the researcher to gain access to the young children's individual meanings in the context of ongoing daily life. Through this
approach to data collection, the researcher sought to develop rich pictures of the children's beliefs (Burns, 2000).

4.5 Data Sources

4.5.1 Context of the participants

Participants for this study were chosen from two primary schools in Brunei. Case Study 1 was conducted in School A and Case Study 2 in School B. Both schools are in the Brunei Muara district and situated about two kilometres from each other. They are both urban schools and displayed comparable dimensions of administrative structure, resource adequacy and infrastructure. Thus, it was anticipated that the Principals, as well as the teachers, would experience similar working conditions. In addition, these schools had children with a wide range of attainment levels accommodated in the same class. Both schools involved in this study were government primary schools. Therefore, only qualified teachers trained either locally, or overseas, were employed. In all of the classes visited, the teachers were local Malays except for 1 Filipino teacher.

School A and School B were purposefully selected (Patton, 1990) so that the majority of the populations of the two schools spoke a similar dialect. The dialect used by both populations was a Malay dialect, a local patois which differs from the standard Malay or the official language of Brunei. However, this dialect is quite similar to the standard Malay language, the language used as the medium of instruction in these schools. Importantly, this is the local patois with which the researcher is most familiar.

4.5.2 Participants

The major source of data used in this study was 255 children, aged between six and 12 years of age from the two primary schools. For Case Study 1, 180 children, aged between six and 10 years were identified from three primary levels. Case Study 1 involved two phases of interviews. Sixty children were randomly selected from each level of Primary 1, 3 and 4 for the first phase of interviews. Fourteen months after the first series of interviews were conducted, 18 children were selected from the
same sample and revisited for more detailed interviews. These children were selected on the basis of their fluency in the original interviews and on the results of the preliminary analysis. At the time of the second interview, these children were already in Primary 3, 5 and 6 respectively. The profiles of the children participating in the second phase of interviews are illustrated in Table 4.3. All names are pseudonyms.

Table 4.3 Profiles of 18 children interviewed in the second phase of Case Study 1.

<table>
<thead>
<tr>
<th>Cases and names</th>
<th>First interview (October 2001)</th>
<th>Second interview (January 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary level</td>
<td>Age</td>
</tr>
<tr>
<td>1. Laila</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2. Rina</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>3. Nora</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>4. Azri</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>5. Elena</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>6. Fitri</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>7. Ahmad</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8. Ali</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>9. Amir</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>10. Nur</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>11. Mohamad</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>12. Osman</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>13. Afif</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>14. Ajib</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>15. Ayu</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>16. Udin</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>17. Wan</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>18. Darina</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

For Case Study 2, children were chosen from a wider range of primary levels. This sample consisted of 75 children aged between six and 12 years. Fifteen children were chosen from each level of Primary 1, 3, 4, 5 and 6. In both Case Study 1 and 2, Primary 2 children were not involved. The reason for not including Primary 2 pupils was twofold. First, it was the aim of the researcher to find the effect of the change of
language of instruction on children’s development of understanding from Primary 4 onwards. Second, as Primary 2 children were taught in the same language as Primary 1 and 3, the pattern of understanding from Primary 1 to Primary 3 was anticipated to reflect the Primary 2 children’s level of understanding. The distributions of children participating in Case Study 1 and Case Study 2 are summarized in Table 4.4.

Table 4.4 Distribution of pupils’ participation in Case Study 1 and Case Study 2.

<table>
<thead>
<tr>
<th>Case studies</th>
<th>No. of children in each primary level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary 1</td>
<td>Primary 2</td>
</tr>
<tr>
<td>Case Study 1</td>
<td>60</td>
<td>-</td>
</tr>
<tr>
<td>Case Study 2</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>-</td>
</tr>
</tbody>
</table>

For both case studies, but especially for Case Study 1, the number of female and male participants was not balanced. For Case Study 1, pupils were chosen at random and since the whole class was allowed to participate, the proportions of females and males were beyond the researcher’s control. Since only 15 children from each level were selected for data collection in Case Study 2, the researcher used the class teachers’ knowledge to identify five high achievers, five average achievers and five low achievers. In Case Study 2, the proportions of females and males were almost balanced. The breakdown of the sample by gender is presented in Table 4.5.

Table 4.5 Sample size by gender

<table>
<thead>
<tr>
<th>Case studies</th>
<th>Primary levels</th>
<th>Number of females</th>
<th>Number of males</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study 1</td>
<td>1</td>
<td>27</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>18</td>
<td>42</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>35</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>70</td>
<td>110</td>
<td>180</td>
</tr>
<tr>
<td>Case Study 2</td>
<td>1</td>
<td>9</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>37</td>
<td>38</td>
<td>75</td>
</tr>
</tbody>
</table>
4.6 Data Collection Techniques

4.6.1 Interview

The principle data collection technique for this study was the interview. The particular style of interview employed in this study was the semi-structured interview, where direction was given to the interviewee so that the content focused on crucial topics that would answer the research questions (Burns, 2000). For Case Study 1, group interviews were used to probe children's understanding of evaporation and condensation. Group interviews as a form of qualitative data collection have now become highly valued and widely used (Patton, 1990). Cohen et al. (2000) outline four advantages of the group interview. First, group interviews enable the potential for a wide range of responses to develop. Second, they involve minimal disruption and are hence timesaving. Third, they bring together people with varied opinions, and finally, they are less intimidating for children. During the pilot study, groups of three were found to be ideal because the children were able to extend each other's ideas and hence a wide range of responses were expressed. The researcher allowed the children to describe their perceptions of, and perspectives on evaporation and condensation. As such, the researcher encouraged them to do most of the talking and the children responded in a relatively uninhibited manner. As these concepts are not formally taught in schools, the children did not know the 'correct' answers and this could be one reason why the children were not 'afraid' to create their own explanations for the phenomena discussed.

For Case Study 2, group interviews were not used to probe pupils' understanding of living and non-living. This decision was based on the researcher's experience during the second pilot study (to be discussed in the next chapter). The children were found to be very enthusiastic about participating in the interviews because the ideas were based on a topic they had learnt at school and were familiar with. As a result, some of the children tended to verbalize the characteristics of living things faster than other children. This resulted in an undesirable situation with the less confident children not being given an opportunity to articulate their ideas. In addition, less competent children were able to copy explanations from others whom they believed were 'cleverer'.
All interviews were conducted in resource rooms. During the interviews, one interview protocol sheet was prepared for each participant and placed in front of the interviewer. As the participants responded to the questions, the interviewer wrote down the answers on the participants' interview protocol sheet.

For upper primary, all interviews were conducted in the English language, and for lower primary, interviews were conducted in Malay. Since an interview is a social encounter, respondents tend to respond in a socially acceptable or socially desirable way (Wiersma, 1986, p. 181). Accordingly, the children in this study responded in the most socially acceptable language. For the lower primary children, this was the Brunei Malay dialect. The researcher could not neglect this dialect as in the actual classroom setting, the Brunei Malay dialect is acceptable for conversation. For the upper primary children, the researcher had to emphasize the use of the English language as the first priority. If the children failed to respond in English but showed the potential to explain their ideas in Malay, the researcher accepted the responses. The Malay responses from the upper primary children were later coded differently and used to compare and examine children's conceptual development both in English and in Malay. This will be explained in more detail in the analysis section later in this chapter.

4.6.2 Limitations of interviews

Patton (1990) believes that the emotional state of the interviewee at the time of the interview could affect the interview data. During interviews, gathering high-quality information is often affected by respondents who are uncooperative, paranoid, sensitive, easily embarrassed, aggressive, timid and hostile (Patton, 1990). According to Patton (1990), misrepresentation and distortion of interview data may result from personal bias, anger, anxiety, politics, and simple lack of awareness. In order to minimize the potential limitations of the interview in this study, the researcher gave considerable attention to establishing rapport with the children being interviewed (Patton, 1990). Rapport was enhanced by having a short informal conversation prior to the more formal interviews. The researcher asked the children about anything that might interest them, for example, bracelet beads they might have been wearing or interesting places that they might have visited. The children were
made as comfortable and relaxed as possible. They were reassured that they were not being tested and that the information gathered from the interview would not influence their marks in any way. To reduce variations in data potentially created by having many interviewers (Patton, 1990), the researcher in this study conducted all of the interviewing herself, both in English and in Malay. In addition, the responses were transcribed and coded only by the researcher in order to reduce the degree of translation error caused by other people who did not conduct the original interviews and were not privy to the subtleties of the conversation.

4.6.3 Interview protocols

Generally, each participant in this study was asked two types of questions; forced-response and open-ended (Wiersma, 1986). The open-ended response questions are better defined as semi-structured interview questions (Burns, 2000). For the semi-structured interview questions, all participants were given the same direction through the use of a written interview protocol. The wording of questions could vary slightly, however, to accommodate different participants’ responses. The forced-response questions differed from the semi-structured questions in that a range of responses were provided in the form of a Likert scale and students were asked to select a response that best suited their ideas (Cohen et al., 2000). Both types of questions were used in a single interview. An example of each type of question follows:

An example of a forced-response interview question:

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We can live without water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

An example of a set of semi-structured interview questions:

- Can you tell me about some things that are not living?
- Why do you think it is not living?
- Is there anything else that makes you think that it is not living?
For each case study, two different sets of interview protocols were designed: one for lower primary and the other for upper primary children. The interview protocol for the lower primary was translated into the Malay language. A bilingual teacher, who has a Bachelor of Malay Literature from the University Brunei Darussalam, vetted the Malay version of the interview protocols for clarity of expression, contextual relevance, regional vocabulary and spelling variations. The interview protocol for the upper primary level, in contrast, was written in English. Since this study involved Primary 1 children, eliciting data through written responses was not possible. As a control procedure to eliminate the possibility of children lacking the reading and writing skills, questions were read to all of the children regardless of primary level. Two different sets of interview protocols were developed for Case Study 1 and Case Study 2. The development of each of these interview protocols is described in the following sections. A summary of the interview response types used in this study is provided in Figure 4.1.

![Diagram](image)

*Figure 4.1 Summary of the interview response types.*

### 4.6.3.1 The development of interview protocols for Case Study 1

Case Study 1 focused on the pupils' understanding the concepts of evaporation and condensation. As children's conceptions of evaporation and condensation have not
previously been investigated in Brunei and these topics are not formally taught at the
primary level, appropriate interview questions were not found in the literature.

One Professor of Science Education from an Australian University and three faculty
members from the Brunei University determined the initial content validity of the
first draft of the interview protocol. One of the faculty members has expertise in the
area of curriculum development while the other two faculty members are science
teacher educators. In the initial stage of development, questions on evaporation and
condensation were drafted and the Professor and three faculty members then were
involved in a review process. The result of this review exercise led to the refinement
of the interview protocol in two significant respects: adjustment of the sections so
that the semi-structured interview questions came before the forced-response
interview questions; and the reduction of the 30-items in the forced-response
interview questions to 23 items for the lower primary and to 26 items for the upper
primary level.

4.6.3.1.1 Forced-response interview questions for Case Study 1

The reduction in the number of items in the forced-response interview questions was
to reduce redundancy and to enhance clarity. The items covered knowledge related
to a) water b) evaporation and c) condensation. The five responses that pupils could
choose for this format were ‘strongly agree’, ‘agree’, ‘disagree’, ‘strongly disagree’
and ‘I don’t know’. A rating of 5 indicated strong agreement with the statement
while a rating of 2 indicated strong disagreement. The response ‘I don’t know’ was
rated as 1.

Items thought to be too easy for the upper primary were omitted and replaced by
more demanding and challenging phrases suitable for older groups of children. One
of the factors affecting comprehension is negation or expressing statements in
negative forms (Clark & Chase, 1972). Thus for the interview protocol used with
upper primary pupils, one item was expressed in negative form (Ice is not water,
rather than ice is water). The inclusion of a negative statement for the older children
was thought to interrogate a greater subtlety of understanding about the concepts. As
a result, two sets of forced-response interview questions were utilised, one for the
lower primary level and the other for the upper primary level. Thirteen items were
shared between the upper and the lower primary forced-response interview protocol. Table 4.6 shows all the shared items of the forced-response interview questions on water, evaporation and condensation.

Table 4.6 The shared- forced-response interview questions on water, evaporation and condensation.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>We can live without water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Water is everywhere.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>There is water in the air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Ice is water (for lower primary levels) or Ice is not water (for upper primary levels).</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Without rain, we will not have water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Evaporation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Washing dries best on a sunny day.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>The water from wet clothes disappears.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Condensation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Rain comes from clouds.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>All clouds contain water vapour.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Water returns to the earth as rain.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>A cup is filled with ice. After 30 minutes, the cup will feel cold and wet.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12.</td>
<td>The water on the outside of the cup comes from the air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>There is water vapour in the air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
4.6.3.1.2 Semi-structured interview questions for Case Study 1

The semi-structured interview questions for Case Study 1 were based on and adapted from Tytler's (2000) material. The four semi-structured questions were divided into two main categories: Section A included three questions, each accompanied by a picture that illustrated the event. Section B included one question about a diagram copied from a Brunei Primary 3 General Studies textbook concerning the water cycle and children were asked to describe the picture in their own words. The picture in the book is used only to explain sources of water to pupils. In this context, the concepts of evaporation and condensation are not taught. The main ideas probed are presented in Table 4.7.

Table 4.7 Similar questions for lower and upper primary in the semi-structured interview questions.

<table>
<thead>
<tr>
<th>Section A</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>One hour after the rain, what would happen to the puddle of water? Why?</td>
</tr>
<tr>
<td>2.</td>
<td>What is happening to the wet clothes as they are hung under the hot sun? Why?</td>
</tr>
<tr>
<td>3.</td>
<td>Water in a dish left under the sun disappears. Why does that happen?</td>
</tr>
<tr>
<td>Section B</td>
<td>4. Describe the picture of the water cycle.</td>
</tr>
</tbody>
</table>

For Section A, rather than having a free flow conversation, a 'standardized open-ended interview approach' (Patton, 1990) was used to ensure the interviewer asked the same initial questions to each participant. For the lower primary children, a sequence of 'closed' probes prior to the main questions in section A was presented (Oppenheim, 1992) with a choice of three alternative replies. For the upper primary, all of the questions were 'open' questions. This was to provide the older children the opportunity to construct their own responses and to allow for flexibility of responses. For the upper primary, there were 7 main questions asked compared with 6 for the lower primary. As shown in Table 4.7, there were four similar questions for the lower and upper primary levels.

The complete interview protocols for evaporation and condensation for lower and upper primary levels are included as Appendix A and Appendix B. The Malay
version of the interview protocol used to guide the interviews for the lower primary children is also included as Appendix C.

4.6.3.2 The development of interview protocols for Case Study 2

Case Study 2 sought to identify children’s conceptions of the concepts of living and non-living. As shown in Appendix D, ‘Living Things’ is the only major topic in the Brunei science curriculum that is taught continuously from Primary 1 to Primary 6.

The format for the interview protocol in Case Study 2 was the same as Case Study 1; semi-structured interview questions and a list of forced-response interview questions. To ensure some measure on content validity, the construction of this interview protocol was directly informed by the syllabus. Content validity of the interview protocol also was determined by two experts, one a Professor of Science Education and the other a faculty member with expertise in the area of conceptual change and children’s understanding of living things (Venville, 2004).

All semi-structured and forced-response interview questions for Case Study 2 were the same for both upper and lower primary levels. This decision was made as a result of the trial where young and old children offered relatively similar views. As a consequence, every participant in this study was given the opportunity to respond to a similar set of questions about living and non-living. The only difference was that the interview protocol for the lower primary was prepared in Malay and for the upper primary English was used.

4.6.3.2.1 Forced-response interview questions for Case Study 2

The first draft of the forced-response interview questions for Case Study 2 consisted of 26 items. For validation purposes, a trial was completed with 6 children. The trial indicated that the questions achieved the kind of responses the researcher hoped for. This draft was then used with a larger pilot group, 5 children from each of the 5 primary levels of 1, 3, 4, 5 and 6. During the trial and the pilot, the children were found to have difficulty understanding some of the questions. The final draft was thus consolidated by reducing 3 items and rewording 2 items. The final forced-
response interview protocol for the concepts of living and non-living thus comprised 23 items with a uniform 5-point Likert scale.

The Likert scale for the forced-response items consisted of 5 ratings. A rating of 5 indicated a strong agreement with the statement while a rating of 2 indicated strong disagreement. The response 'agree' and 'disagree' are rated 4 and 3 respectively. Whilst the response 'I don't know' was rated 1. The list of all items on the forced-response interview protocol for the concepts of living and non-living is shown in Table 4.8.

Table 4.8 The forced-response interview questions for the concepts of living and non-living.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All things in this world fall into two main categories of living and non-living.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Living things are things that are alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>A human being is alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Cats, birds and fish are all alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Plants, trees and flowers are all alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Something that is 'alive' has life! It is not an object and it is not dead.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Things that are alive can die.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Things that are alive need food to give them energy.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Things that are alive grow.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Things that are alive can reproduce or have babies like themselves.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>A newborn baby grows into an adult.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12.</td>
<td>Seeds grow into new plants.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>If something is living it can move and grow. If it cannot move and grow, it is non-living.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 4.8 (continued)

| 14. | Smoke is moving but it is not living because it cannot grow and reproduce. | 5 | 4 | 3 | 2 | 1 |
| 15. | Animals and plants breathe. | 5 | 4 | 3 | 2 | 1 |
| 16. | Plants can protect themselves. | 5 | 4 | 3 | 2 | 1 |
| 17. | Animals are different in the way they breathe. | 5 | 4 | 3 | 2 | 1 |
| 18. | Animals produce young in different ways. | 5 | 4 | 3 | 2 | 1 |
| 19. | Plants need water, sunlight and air to make food. | 5 | 4 | 3 | 2 | 1 |
| 20. | Fins help fish to swim and balance their body. | 5 | 4 | 3 | 2 | 1 |
| 21. | Fish can breathe in the water because they have gills. | 5 | 4 | 3 | 2 | 1 |
| 22. | Certain animal populations feed on another populations. | 5 | 4 | 3 | 2 | 1 |
| 23. | A human being is an animal. | 5 | 4 | 3 | 2 | 1 |

4.6.3.2.2 Semi-structured interview questions for Case Study 2

Most of the semi-structured interview questions for Case Study 2 were developed from Venville’s (2004) materials and crosschecked with the Brunei primary curriculum. Questions from this previous study were used because they had already been validated showing reliable results. A few demanding questions were included for the children from all primary levels who had a sound understanding of the concepts of living and non-living.

The open-ended questions were structured using an interview protocol designed to probe the children’s understanding of the concepts of living and not living. One of the semi-structured interview questions in Case Study 2 is the categorization task (question no. 5, Table 4.9). This task sought to ascertain the criteria children use to decide whether an object/organism can be classified as living or non-living. Picture cards representing the objects were included in the interview protocol and were shown to the children.
Table 4.9 *The semi-structured interview questions on the concepts of living and non-living.*

1. Can you tell me some things that are living?
   - Why do you think that (the above example(s)) is/are living?
   - Are there any other things that make you think [that] is living?
   - Anything else that helps you to think [it] is living?

2. Can you tell me about some things that are not living?
   - Why do you think [it] is not living?
   - Is there anything else that makes you think [that] is not living?

3. Was a dead cat ever living?
   - Do you know some things that have never been living?
   - Do you think [it] is not living?
   - Why do you think that [it] is not living?

4. Do you know what living means? What does it mean?

5. (Ask the child the following questions about fire, table, car, person, plant, cat, television, cloud, house and bird)
   - What do you think this is?
   - Do you think [this] is living or not-living?
   - What makes you think it is living / not living?
   - Is there anything else that makes you think [that] is living / not-living?

6. (Ask the child the following questions about a group of animals consisting of a cow, a dog, a pigeon, a lizard, a snake, a frog, a fish and a person)
   - (Picture cards were provided and shown to the children)
   - In how many ways can you group the animals?
   - Explain in your own words how you decided on the groupings.
   - In what ways are these animals similar?
   - In what ways are these animals different from each other?
   - Do you think all these animals are living?
   - What can you say about the characteristics of the animals above?

7. (Ask the child the following questions about a group of animals and a group of plants)
   - (Picture cards were provided and shown to the children)
   - Explain in your own words how you decided on the grouping?
   - In what ways are these things similar?
   - In what ways are these different?
   - Do you think these things are living or not-living?
   - In what ways are these things different from (use child’s example of non-living)?
A trial was administered to 6 children to validate the interview protocol. During this trial, it became evident that some of the children were confused by the sequence of the questions. To overcome this unexpected difficulty, the sequence of questions was reordered. The final version of the interview protocol included 28 questions that were grouped into 7 main ideas as outlined in Table 4.9. The complete English and Malay versions of the semi-structured interview protocols on living and non-living are included as Appendix E and Appendix F.

4.6.4 Classroom observation

Patton (1990) reveals that, 'no single source of information can be trusted to provide a comprehensive perspective on the program' (p. 244). Interviewing Brunei children was challenging because they are not used to offering their views freely in a classroom setting and also found it difficult to express their views freely during an interview. To crosscheck findings reported in interviews, classroom observations also were conducted. The focus was on teaching strategies used and, in particular, the researcher aimed to explore how the teacher-child interaction pattern influenced the way in which children offered their views.

The researcher gathered data during 15 classroom observations. Observations were carried out in School A and School B after all interviews were completed. The classes were visited during Science (for upper primary classes) and 'Pelajaran Am' or General Studies periods (for lower primary classes). Table 4.10 provides a summary of these classroom visits. Each observation lasted for approximately 1 hour.

The classroom observations were not structured, the locus of control remained with the teacher and the classroom agenda was determined by the teacher and children (Cohen et al., 2000). In order to explore the teacher-child interaction and how this influenced the way children expressed their views, the researcher focused on the questioning techniques of the teachers in exercising open-ended questions or questions that required children to recall information and apply information to new contexts. Data were recorded through field notes taken by the researcher. In particular, the teachers' and children's distinctive verbal interactions and behaviour were noted. Even though the researcher focused on verbal interactions, audio-
recording facilities were not used. While recording may ensure that none of the fine details of conversation are omitted, high priority was given to reducing anxiety for the teachers being observed. Teachers in Brunei are rarely observed and the least invasive strategy of field note taking was selected to ensure that lessons ran in a natural way. As a non-participant observer (Burns, 2000), the researcher did not participate in any activities or interactions that took place in the classrooms. The teachers involved were informed one week before the researcher made the visits. The ethical issues about access to the classroom are addressed later in this chapter.

Table 4.10 The summary of classroom visits.

<table>
<thead>
<tr>
<th>Classes visited</th>
<th>Science topic taught</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School A</strong></td>
<td></td>
</tr>
<tr>
<td>Primary 1B</td>
<td>Time</td>
</tr>
<tr>
<td>Primary 1C</td>
<td>Things in the living room</td>
</tr>
<tr>
<td>Primary 2A</td>
<td>Map and symbols</td>
</tr>
<tr>
<td>Primary 2B</td>
<td>Negara Brunei Darussalam in general</td>
</tr>
<tr>
<td>Primary 5A</td>
<td>Mammals, reptiles, amphibians, birds and fish</td>
</tr>
<tr>
<td>Primary 5B</td>
<td>Infectious diseases</td>
</tr>
<tr>
<td><strong>School B</strong></td>
<td></td>
</tr>
<tr>
<td>Primary 1A</td>
<td>Animals that live in water</td>
</tr>
<tr>
<td>Primary 1A</td>
<td>Animals that live on land and animals that fly</td>
</tr>
<tr>
<td>Primary 3A</td>
<td>Introduction to plants</td>
</tr>
<tr>
<td>Primary 3A</td>
<td>Ways that plants protect themselves</td>
</tr>
<tr>
<td>Primary 4B</td>
<td>Food test</td>
</tr>
<tr>
<td>Primary 4B</td>
<td>Our basic needs: water, food, shelter and air</td>
</tr>
<tr>
<td>Primary 5C</td>
<td>Sources of light</td>
</tr>
<tr>
<td>Primary 5C</td>
<td>Transparent and translucent objects</td>
</tr>
<tr>
<td>Primary 6A</td>
<td>Science revision</td>
</tr>
</tbody>
</table>

4.6.4.1 Classroom observations in School A

Classrooms observations in School A were conducted in March 2002. Six teachers were approached, two of whom gave their consent willingly. The remaining 4 teachers reluctantly allowed the researcher to visit their class on one occasion only. Six science classes were observed in School A. Four classes were selected in the
lower primary level and therefore the lessons were conducted in Malay. In lower primary classes, science, geography and history are taught as an integrated subject known as the General Studies subject. Two science lessons, which were conducted in English, were observed in the upper primary level. One local and one Filipino teacher taught the lessons. One lesson was on the classification of animals and the other on infectious diseases. No practical lessons were observed.

4.6.4.2 Classroom observations in School B

In School B, nine classroom observations were completed. Four teachers gave their consent for the observation. A class representing each primary level was visited twice except for Primary 6 which was visited only once because the teacher was busy preparing the children for the public examination or the Primary Certificate of Education examination (PCE). Four lessons were observed in the lower primary levels and five from upper primary. During both visits to Primary 5A, science lessons were carried out in a science laboratory. Interestingly, the researcher was informed by a few pupils during the first session that it was their first experience learning science in that laboratory. The visit was conducted in September 2002, two months before the school year ends! The laboratory was equipped with many materials suitable for science activities that had seemingly been left ‘untouched’ at the back of the room. The room was dusty, so were all the materials. When asked, the teacher said the room had not been used for that year because a science coordinator had not been assigned responsibility for the room.

The field notes were first rewritten in more meaningful texts, highlighting the descriptions of the teacher’s questioning techniques. The notes from each classroom observation were then examined and a summary was constructed for each observation. The summary was crosschecked with the raw observation data.

4.6.4.3 An overview of classroom language use

In all classrooms the researcher observed, the majority of teachers used relevant methods and pedagogic skills appropriate for science teaching, but they did not provide opportunities for language development. The following points highlight these language development constraints.
Almost all Primary 4, 5 and 6 children continuously talked in Malay when they were talking about science and socialising during classroom activities.

Primary 4 children asked questions in Malay and the teacher(s) responded in English. For example, ‘Apa warnanya ni cikgu?’ (What colour is this?)

Almost all Primary 4, 5 and 6 teachers used a combination of both languages (English and Malay) in single sentences. For example, “This food on the table, we want to test sama ada ia (whether or not it) contains starch” and “That means potato, bread, rice and flour contains kanji (starch)”.

Most of the time, the Primary 1, 3, 4, 5 and 6 teachers posed closed questions. The answers expected were either ‘yes’ or ‘no’ or another one word answer.

In the event that the Malay language was used as the language of instruction, Brunei dialects were occasionally used. In fact, on one occasion, a Primary 3 teacher used Brunei dialect words continuously throughout the lesson. For example, the teacher used the word ‘tukup’ (which means to cover). In standard Malay, this word is pronounced as ‘tutup’.

In four of the 7 upper primary classes observed, Malay was used by the teachers and by the pupils. Table 4.11 summarizes the approximate frequency of Malay sentences used in these four classes.

Table 4.11 Frequency of Malay sentences used in four upper primary classes.

<table>
<thead>
<tr>
<th>Type of Interaction</th>
<th>Frequency</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher to child</td>
<td>10</td>
<td>n=10</td>
</tr>
<tr>
<td>Teacher to children</td>
<td>12</td>
<td>n=12</td>
</tr>
<tr>
<td>Child to teacher</td>
<td>22</td>
<td>n=22</td>
</tr>
<tr>
<td>Child to child</td>
<td>17</td>
<td>n=17</td>
</tr>
<tr>
<td>Child to teacher</td>
<td>11</td>
<td>n=11</td>
</tr>
</tbody>
</table>
From the classroom observations, it seems that the teachers were trying to deal with their insecurity about their proficiency in both the English language and the Malay language by avoiding complete English sentences, not encouraging discussion, relying to some extent on the use of local dialect and allowing two languages to interact in the same discussion. The classroom observation provided data that suggested that teachers also were under pressure from pupils to speak in Malay. The researcher encountered many situations when the children (in the upper primary levels) used the following questions and expressions:

- ‘Boleh ku cakap melayu cikgu?’ (May I speak in Malay?)
- ‘Apakan kita cakap ani?’ (What are you talking about?)
- ‘Inda saya faham cikgu!’ (I don’t understand what you’re talking about.)
- ‘Boleh cikgu terangkan dalam bahasa melayu?’ (Can you explain that in Malay?)

In one of the Primary 5 lessons observed by the researcher, the teacher focused on the concept ‘animal’. It was an interesting lesson from the pupils’ point-of-view, but throughout the one-hour lesson, the teacher never once mentioned human beings as an example of an animal. A lesson précis is presented in Figure 4.2.

Along with the teacher’s failure to elaborate on animals, the influence of home language also appeared to have impacted on the development of the pupils’ ideas about living. In Brunei, there are many different meanings for the word ‘hidup’. Some of the subtle differences and uses of this word include, ‘kucing itu dikubur hidup-hidup’ (the cat was buried alive), ‘hidupkan semangat kejiranan’ (to promote neighbourliness spirit), ‘menghidupkan enjin kereta’ (start the car engine), and ‘kehidupan’ (life). The children who have limited experience and have only been exposed to the everyday meaning for ‘hidup’, would be likely to have a less sophisticated way of perceiving this word. Language enables the children to name things they see. Through experience, they will eventually be able to use the language appropriately in different contexts such as the everyday context and the scientific context. Similarly, there are several occasions when Malay speaking people use the English word ‘again’ when referring to ‘what’s next’. The following dialogue demonstrates how ‘again’ was used inappropriately in one of classes observed.
Q: In what ways are these animals different from each other?
A: Some live in water others live on land.
Q: 'Again?' (Is there anything else that makes you think they are different?)
A: It’s the way how they reproduce!

<table>
<thead>
<tr>
<th>Time</th>
<th>Activities</th>
</tr>
</thead>
</table>
| 10.00 am | • Teacher entered the classroom  
|         | • Read the prayer |
| 10.05 am | **Activity 1** |
| Teacher: | Animals can be divided into…? |
| Children: | Two! |
| Teacher: | What are those, Wan? |
| Wan: | Animals with backbones and animals without backbones. |
| Teacher: | Can you name ….. er….now these animals with backbones can be further divided into…? Amir? |
| Amir: | Five! |
| Teacher: | Zaman, Imah, Atul and Izan… write down on the board (all those groups of animals with backbones).  
|         | (The children went to the front and wrote on the board the five groups classified as animals) |
| Teacher: | Are all correct class? |
| Children: | Yes… |

**Activity 2**

| Teacher: | Tell me where (in which categories) these animals fit into? Now, you (pointing to a girl), a cat? |
| Girl: | Mammal?! |
| Teacher: | Laila, a snake? |
| Laila: | Reptile! |
| Teacher: | You (pointing to a boy), an eagle? |
| Boy: | Bird!  
|         | (This activity continued with the teacher asking the children about ‘piranha’, ‘cow’, ‘frog’ and ‘lizard’) |

**Activity 3**

| Teacher: | Now, what are the characteristics of mammals, Nur? |
| Nur: | Warm blooded! |
| Teacher: | Yes, what else? |
| Child A: | Give birth to young ones! |
| Child B: | Feed their baby (babies) with milk!  
|         | (The Teacher wrote on the board what the children said) (Similar patterns of activity were seen with reptiles, birds, fish and amphibians) |

*Figure 4.2 A lesson précis.*
10.25 am  Teacher: Now, I want you to do these exercises.
   • Teacher distributed papers to the children.
   • Teacher explained the questions.
   • Children started doing their work.
   • Teacher went round the classroom and checked the children’s work.

10.40 am
   • Teacher sat on the teacher’s desk.
   • Children continued their work.

10.46 am
   • Teacher marked the children’s papers.
   • Teacher called the children who had made mistakes and explained individually.

11.00 am  Class ended.

Figure 4.2 (continued)

The children’s lack of familiarity and experience with English words and sentences were highlighted through inefficient expressions in English. A sufficient command of English for interaction in English-speaking classes was not evident in the pupils and the teachers in the classes observed.

4.7 Data Collection Procedures

In planning the schedule for the fieldwork, many things were taken into consideration. School term holidays, public holidays and term examinations were checked before making the trip to Brunei. However, unavoidable circumstances resulted in the researcher having to cancel and reschedule some visits, for example children were absent from school and classes were cancelled because of official functions.

Before the fieldwork commenced, the researcher identified the schools. The researcher then met with the respective Principals and advised them about the purpose of the fieldwork and requested permission to enter the school for this purpose. The researcher then sought permission from the Ministry of Education. Fieldwork started once the application was approved.

Data collection in School A started in late October 2001 and proceeded until November 2001. Prior to this, Pilot Study 1 was conducted in June 2001. This was
followed by a series of classroom observations in March 2002. Data collection in School B commenced in early July 2002. Again this was preceded with a pilot study conducted in May 2002. In January 2003, 18 children selected from the Case Study 1 sample population were revisited for detailed interviews. A summary of the data collection schedule is presented in Figure 4.3.

School A: Case Study 1 Evaporation and Condensation

- Pilot study: June 2001
- Interviews: Oct – Nov 2001
- Classroom observation: March 2002
- Detailed interviews: January 2003

School B: Case Study 2 Living Things

- Pilot study: May 2002
- Interviews: June – July 2002
- Classroom observation: September 2002

Figure 4.3 Summary of data collection schedule.

4.8 Interpretation and Analysis of Data

4.8.1 Analysis of interviews for Case Study 1 and Case Study 2

For the purpose of gaining the big picture of children’s understanding, the majority of the data from the two case studies were analysed statistically by using the Statistical Packages for Social Sciences (SPSS) computer software. Total scores for the forced-response interviews were calculated by entering scores based on the 5-point Likert scale into SPSS. For verbal data from the majority of the semi-structured interviews, responses were first manipulated before they were systematically entered into SPSS. The raw interview data were analyzed by first segmenting the transcribed data into responses that indicated a similar idea about a
particular phenomenon. Each group was then summarized and labelled. The labelled information was then entered into SPSS for analysis. Examples of the groups for each case study are presented below:

Case Study 1:

Question A2b: One hour after the rain, what would happen to the puddle of water? Why?

<table>
<thead>
<tr>
<th>Labelling</th>
<th>Children’s responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No response</td>
</tr>
<tr>
<td>1</td>
<td>Water is deep</td>
</tr>
<tr>
<td>2</td>
<td>Water goes to the earth</td>
</tr>
<tr>
<td>3</td>
<td>Water disappears</td>
</tr>
<tr>
<td>4</td>
<td>Drizzling</td>
</tr>
<tr>
<td>5</td>
<td>[because of the] wind/ dry by itself</td>
</tr>
<tr>
<td>6</td>
<td>[because of the] wind/ [water] goes to the earth</td>
</tr>
<tr>
<td>7</td>
<td>Water goes through holes/ drains</td>
</tr>
<tr>
<td>8</td>
<td>Raining</td>
</tr>
<tr>
<td>9</td>
<td>Water goes up</td>
</tr>
<tr>
<td>10</td>
<td>Water goes to the sky</td>
</tr>
<tr>
<td>11</td>
<td>Water goes up/ to the sky</td>
</tr>
<tr>
<td>12</td>
<td>Sun heats [the water]</td>
</tr>
<tr>
<td>13</td>
<td>Rain stops</td>
</tr>
<tr>
<td>14</td>
<td>Flooding</td>
</tr>
<tr>
<td>15</td>
<td>[water] far from drains</td>
</tr>
<tr>
<td>16</td>
<td>Water rises from the earth</td>
</tr>
</tbody>
</table>

Case Study 2:

Question A4: Do you know what living means? What does it mean?

<table>
<thead>
<tr>
<th>Labelling</th>
<th>Children’s responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No response</td>
</tr>
<tr>
<td>1</td>
<td>Move</td>
</tr>
<tr>
<td>2</td>
<td>Grow</td>
</tr>
<tr>
<td>3</td>
<td>Need food</td>
</tr>
<tr>
<td>4</td>
<td>Breathe</td>
</tr>
</tbody>
</table>
Move and grow
Move and breathe
Move, grow and need food
Move, grow, need food and breathe
Move, grow, need food and reproduce
Move and need food
Move, need food and breathe
Move, hunt for food and hide for predators
[living things] have hearts, lungs and livers; move
Move, grow, need food, breathe and reproduce
Move, need food, breathe and reproduce

Frequency distribution and statistical analyses were performed, separately or simultaneously, depending on the need to answer particular research questions. To test whether or not significant differences existed between primary levels in the children's conceptual understanding, analysis of variance (ANOVA) was employed. The results of the ANOVA were followed by Scheffe's pair-wise comparison analyses to locate the area(s) of difference.

Two of the questions from the semi-structured interview in Case Study 2 on living and non-living were analysed separately. These were question 1 and question 5, the categorization task (Table 4.9, p. 90). For question 1 of the semi-structured interview section of Case Study 2, marks were awarded to children who were able to use scientifically acceptable criteria for describing living and non-living things. One mark was given for each of the criteria of 'movement', 'growth' and 'nutrition'. Two marks were given for each of 'breathing', 'reproduction' and 'excretion', because these criteria are more abstract. Finally, children who correctly used the criteria of 'irritability' or 'response' to describe living and non-living things were awarded 3 marks because these criteria were thought to be the most sophisticated and conceptual.

For the categorization task (question 5), children's responses also were entered into the SPSS software package. The number of children who thought the items in each question were living was counted and a bar chart was produced. In addition, each child was given a score. Each correct response was awarded 1 point and 0 points
were awarded for an incorrect response. Since there were 10 categorization activities, the maximum score was 10. A correct response was based on whether the child was able to correctly categorize each phenomenon in the pictures as living or not living. Descriptive statistical data were generated and a line chart was produced.

4.8.2 Analysis of the data for evidence of conceptual change

For the concepts of evaporation and condensation, evidence for conceptual change was analysed from both ontological and epistemological perspectives. Two conceptual change models were, therefore, utilised to determine patterns of development of understanding. First, Chi’s ontological categories and second, the epistemological conceptual change model developed by Posner et al. (1982) and researched extensively by Hewson and Hewson (1992) and Hewson and Thorley (1989) (see Table 3.1 in previous chapter).

For the concepts of living and non-living, evidence of conceptual change was determined only from an ontological perspective. Additional detailed interviews required for analysis from an epistemological perspective were not carried out for this case study due to time constraints. For the concepts of living and non-living things, Carey’s (1985) ontological conceptual change model was employed as an analytical framework (this will be discussed later in section 4.8.5).

In an attempt to answer the research questions and in particular to ascertain if there was any evidence for conceptual change, a comprehensive framework for the purpose of interpreting the data was developed. This framework is explained in detail in the following sections.

4.8.3 Evidence of conceptual change from an ontological perspective about the concepts of evaporation and condensation

The main source of data for the ontological categorization of the children’s knowledge about the concepts of evaporation and condensation were the four main questions of the semi-structured interview that used picture cards to prompt pupils’ ideas about particular scenarios:
- What would happen to the puddle of water, one hour after the rain? Why?
- What is happening to the wet clothes as they are hung under the sun? Why?
- Water in a dish left under the sun disappears. Why does that happen?
- Describe the picture of a Water Cycle.

As the semi-structured interview questions were open-ended, numerous responses were given by the children. The data from interviews are words (Patton, 1990), therefore, Burns (2000) suggests that the first stage in analyzing the interview data is to classify the raw data into themes, issues, topics, concepts, and propositions, a process known as coding (Chi, 1997). Accordingly, the children’s verbal responses were analyzed by first sorting the transcribed data into groups. Each group was then coded. The coding was based on the coding developed by Russell and Watt (1990) and Russell, Harlen and Watt (1989), as shown in Table 4.12. The explanation types in the Russell et al.’s coding vary from one another in terms of the degree of difficulty and are arranged systematically from the most simple to the most sophisticated responses. There are nine explanation types, explanation Type 1 is the simplest and explanation Type 9 is the most sophisticated. As the explanation types are ordered in terms of degree of increasing complexity, scores were awarded to the children based on the explanations they provided (as shown in Table 4.12).

For Primary 1 and 3 pupils, questions were asked and responses were provided in the Malay language. For Primary 4, questions were asked in English and the children gave responses in two languages - in English if they were able to explain the phenomena in this language and in Malay if their English language competency was not adequate for the kind of responses they wanted to give. Children’s responses in English were prioritized.
Table 4.12 *Coding generated for responses to the evaporation and condensation semi-structured interview questions.*

<table>
<thead>
<tr>
<th>Types of response</th>
<th>Description of responses</th>
<th>Score awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Uncodeable</td>
<td>Either a 'don’t know' response or the response does not make sense or is sufficiently unusual not to fit into another category.</td>
<td>1</td>
</tr>
<tr>
<td>2. Perceptual</td>
<td>Refers to responses like “it dries up”, “the water is steaming and bubbling”, “the water is heating”, “the alcohol disappeared”, which focuses upon perceptual elements of what is happening only.</td>
<td>2</td>
</tr>
<tr>
<td>(descriptive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Displacement</td>
<td>The liquid changes position, but not form, as in “dripping to the ground”, “soaking in”.</td>
<td>3</td>
</tr>
<tr>
<td>4. Water cycle image</td>
<td>Refers to responses that mention the water going to the sky, or the sun, or the clouds. These might also mention rain.</td>
<td>4</td>
</tr>
<tr>
<td>5. Evaporation</td>
<td>The use of the word only, without elaboration.</td>
<td>5</td>
</tr>
<tr>
<td>6. Evaporation and water cycle image</td>
<td>A combination of the previous two categories, as in “it evaporates up to the clouds”.</td>
<td>6</td>
</tr>
<tr>
<td>7. Water goes into air or atmosphere</td>
<td>A reference to water going into the air. These responses may or may not use the word evaporation.</td>
<td>7</td>
</tr>
<tr>
<td>8. Changes to perceptible form</td>
<td>Water changes to a form which can be seen or felt, such as steam, or mist or fog, moisture.</td>
<td>8</td>
</tr>
<tr>
<td>9. Changes to imperceptible form</td>
<td>Involves reference to vapour, or gas, or particles in the air.</td>
<td>9</td>
</tr>
</tbody>
</table>
Classifying the children's knowledge into ontological categories was quite challenging. Chi (1992) concurs that even though distinctions can easily be captured, ontological categories are difficult to define. In an attempt to divide the children's knowledge into groups, an idealized ontology where each category was described as being ontologically distinct from the others was developed. Figure 4.4 shows the three basic ontological categories: matter, event and abstraction. Matter has ontological attributes that can be observed by the children. For example; “water is deep”, “water disappears”, “rain stops” and so forth. In contrast, ontological attributes in the events category cannot be observed. For example, “water goes up to the sky”, is an example of an explanation that does not have an observable ontological attribute. The abstraction category reflects another distinct set of attributes. Even though abstractions also possess properties that cannot be observed, they remain ontologically distinct from events. For example, “water goes up to the sky”, is classified in the event category if an attribute that explains why the children thought so is lacking. “Water goes up to the sky” is classified in the abstraction category if a defining attribute that explains how the child ‘assumes’ water goes to the sky is included. For example, “water goes up to the sky because it is sucked up by the sun”. In sum, responses in the abstraction category provide the theoretical explanations to the responses classified into the event category.

Based on the ontological categories described above, the nine types of children's explanations (Table 4.12) were grouped as shown in Figure 4.4. Figure 4.5 elaborates with examples the attributes for each of the three categories, matter, event and abstraction.

The perceptual and displacement responses were classified into the ontological category of matter because responses such as “the water is bubbling” and “the water drips to the ground” are based on ontological attributes that can be observed by the children. Conversely, the water cycle image responses were classified into the category of events because responses such as “water goes to the sky” and “water goes to the sun” reflect another set of attributes that reflect an event ‘occurring’, that cannot be observed by the children. Finally, the evaporation, evaporation and water cycle image, water goes into air or atmosphere, water changes to perceptible form and water changes to imperceptible form types of responses were viewed as
belonging to the third ontological category of abstractions. Even though responses in this category such as “water evaporates” and “water goes into the air” have attributes that are non-observable they include an explanation or better understanding of the phenomena. For instance, “water goes to the sun” is classified in the event category because it is not clear how the child thought that water goes to the sun. A response, such as “water goes into the air”, has a stronger scientific quality. Not only did the explanation have attributes that could not be observed, the explanation indicates that the child understands that there is actually water in the air. In this respect, the category of abstraction offers a set of attributes that are more theoretical and complex.

![Diagram](image)

**Figure 4.4** Three ontologically distinct categories of children’s verbal responses about evaporation and condensation.
Figure 4.5 An idealized ontology of children’s knowledge on the concepts of evaporation and condensation (adapted from Chi, 1992).
4.8.4 Evidence of conceptual change from an epistemological perspective about the concepts of evaporation and condensation

Eighteen children were revisited 16 months after they were first interviewed in 2001. Participants were purposefully selected so that the sample would include children with conceptions of evaporation in each of Chi’s three basic ontological categories; matter, events and abstraction. Two children from each of the three ontological categories from each level, Primary 1, 3 and 4, were re-interviewed in 2003 in order to ascertain the status of their conceptions. At the time of the second visit, the children were in Primary 3, 5 and 6 respectively. Primary 5 and 6 children were interviewed twice, once in English and again in Malay. All interviews were transcribed and interview transcripts were scrutinized for elements that indicated the status of their conceptions.

During the second interview, children were asked to give explanations to one of two situations:

- What would happen to wet clothes a few hours after they are hung in the hot sun?
- What would happen to the road a few hours after the rain?

The analysis of this data was based on the conceptual change model developed by Posner et al. (1982) and researched extensively by Hewson and Hewson (1992) and Hewson and Thorley (1989). This model identifies the status of the children’s conceptions as being intelligible, plausible and fruitful. In this regard, the concepts of evaporation and condensation are intelligible to the pupil if the pupil is able to find a way of representing the scientific concepts. When the pupil consistently believes that their conception about the concepts is true, it is said to be plausible. Finally, the concept is said to be fruitful to the pupil if the conceptions are intelligible, plausible and the pupil is able to make connections with other conceptions and transfer the idea to a new situation. In order to determine the status of a person’s conception, Hewson and Hewson (1992) outlined three crucial steps. First, identify representations of conceptions within the person’s statements. Second, identify comments or statements about the conception. The statements are metaconceptual in nature if they comment about the conception. The statements can
be either technical or non-technical. Finally, the statements of representations and
metaconceptual comments are identified using the conceptual change model.

In an attempt to identify the status of the children's conceptions about evaporation
and condensation a search for indicators in the form of 'key words' was performed.
A systematic method of classification of the children's interview responses was,
therefore, developed. Figure 4.6 shows how the status of the conceptions was
identified as either intelligible, plausible and/or fruitful.

Figure 4.6 Evidence used to classify the status of conceptions as intelligible,
plausible and fruitful.
An important aspect of identifying the status of children’s conceptions is whether or not the pupil is able to explain the phenomena. This indicates the pupil’s conception is intelligible, for example, if he or she is able to explain that water goes into the air. If the pupil is then able to assimilate (Posner et al., 1982) the new knowledge (water in the air) with their existing knowledge (rain), then this makes the new knowledge (water in the air) plausible to that pupil. In other words, the pupil can link the idea that water is in the air with the idea of rain. Making this connection helps to demonstrate that the pupil believes that water really goes into the air. However, it is difficult to decide whether or not the new conception is plausible especially when the pupil does not make any direct statement about whether he or she ‘believes’ that water goes into air or not. In this regard, the researcher identified a few keywords as indications that the pupil believes that his or her new knowledge was true. For example, even though the phrase “just like that” does not explicitly indicate the pupil believes the conception, the researcher identified this phrase as indicating a certain level of confidence that means the explanation is quite satisfying for that particular pupil. Whereas if the pupil said, “I don’t know how it goes up”, this phrase clearly indicates that the pupil does not believe that the phenomenon is true. Similarly, the use of the word ‘must’ indicates that the pupil firmly believes that water does go into air. The central idea becomes fruitful to the pupil if he or she is able to apply (Posner et al., 1982) the idea that “water goes into the air” to a new and different phenomenon. For example, a pupil makes a connection between water in the air and dew. Here, the pupil relies on his or her current concept that “water goes into the air” to organize his investigation of a new phenomenon, the dew.

The status of a conception is increasingly cognitively demanding as it moves from being intelligible to plausible and then to fruitful. Thus, the more conditions that can be met, the higher the status of the pupil’s conception (Hewson & Hewson, 1992).

4.8.5 Evidence of conceptual change from an ontological perspective about the concepts of living and non-living things

The second cluster of science concepts that was investigated in this study, living and non-living, appear to initially have branches such as animal, plant and human being that eventually merge in most children’s minds to form a superordinate category of
living thing. The structure of the forced-response interview questions shaped the children’s responses to identify their ideas about the characteristics of living things. Carey (1985) and Chi (1992) point out that even though plants and animals have different ontological attributes and thus are placed under different ontological categories, they both belong to the same superordinate category of ‘living things’. Thus, the critical distinction between the ontological categories for the concepts of evaporation and condensation and the concepts of living and non-living is that the kind of change for the concepts of living and non-living is within (not across) an ontological tree.

In an attempt to answer research question 2d about the ontological categories of the concepts of living and non-living, this study utilized the basic conceptual framework formulated by Carey (1985) (Figure 4.7).

![Ontological categories diagram](image)

*Figure 4.7 Carey’s (1985) categories of ontologically basic concepts.*

The development of ontologically distinct categories by Carey (1985) was based on a linguistic test. A predicate (indicated in quotation marks in Figure 4.7) will modify all the concepts within the same branch, even if it is false. When predicates from a different branch of the same tree or from totally different trees are used to modify concepts on another branch or another tree, the statement does not make sense. For
example, "The thunderstorm is broken". Such a statement is called a category mistake (Carey, 1985; Chi, 1992). The alternative statement "The thunderstorm is unbroken", also does not make sense. Category mistakes are thus said to be 'wrong' in a stronger sense than merely being 'false' (Carey, 1985). A predicate is said to 'span' a term if it can be applied sensibly to a term, even if it is not true. The world's conceptual system includes an enormous number of concepts. Interestingly, very large numbers of predicates span the same concepts, thus enabling the concepts to be clustered as a few ontologically basic categories.

The first of Carey's (1985) basic ontological categories is the category 'physical object' (Figure 4.7). From this basic category, hundreds of thousands of concepts of different kinds of things can be categorized at the next level of living and non-living. The concept living has at least two separate categories, 'animals' and 'plants'. 'Plants' cannot become a part of 'animals'. Thus, even though 'animals' and 'plants' can merge to form a superordinate category 'living', the two categories are said by Carey to be distinct. Conversely, Chi (1992) maintains that the kind of conceptual change involving the integration or the coalescence of 'animals' and 'plants' into the 'living things' category is conceptual change within an ontological category. Carey’s basic ontological category 'physical objects' is similar to Chi’s 'matter' because, first, they constitute the ontologically basic categories of a conceptual system and second, they have a certain set of behaviours that govern the attributes of one basic ontological category.

In sum, the judgment of category errors, resulting from the incorrect use of predicates in natural language, can be used to diagnose incorrect ontological categories. Moreover, the developmental changes in judgments of category errors can play a part in the description of ontological development (Carey, 1985). For example, Carey's data showed that four to seven year old children not only consider plants not to be alive, they consider it a category mistake to attribute certain basic biological states to them. By age ten, they can finally correctly represent the concept living thing with the same extension as adults, that all animals and plants are alive. The assumption is that the formation of the superordinate category, living, is clearly developed through the natural maturation processes. This study investigated whether or not this assumption can be supported with evidence of Brunei children across the
primary levels 1 – 6 by analyzing the structure of predicates that these children constructed.

The value of any research depends on people's confidence in its potential to provide trustworthy results. "They are trustworthy to the extent that there has been some accounting for their validity and reliability" (Merriam, 1998, p. 198). Merriam (1998) later declares that ensuring validity and reliability in qualitative research also involves "conducting the investigation in an ethical manner" (p. 198). In the following sections, the details of research rigour and ethics that were taken into consideration during the development and implementation of this study are explained.

4.9 Research Rigour

Rigour is the hallmark of trustworthiness. Without rigour, research cannot be recognized. This study produced both qualitative as well as quantitative data even though all data were collected by means of systematic interviewing (Yin, 1994). Therefore ensuring rigour from both the quantitative and qualitative paradigmatic perspectives was considered not only to be necessary, but also to enhance the rigour in itself. Several researchers explain that each paradigm possess its own specific criteria for rigour (Guba & Lincoln, 1989; Lincoln & Guba, 1985; Patton, 1987). In the following paragraphs, the criteria for judging the soundness of the two aspects of this research are explained.

4.9.1 Quantitative data

Within the quantitative paradigm, the criteria that have evolved in response to the goodness and quality of the research are ‘validity’ and ‘reliability’.

4.9.1.1 Validity

Ascertaining validity involves issues of truth and correctness of a statement (Kvale, 1996) and whether you are measuring what you think you are measuring. Validity comes in two forms, internal and external. Internal validity is defined within the positivist paradigm as 'the extent to which variations in an outcome or dependent
variable can be attributed to controlled variation in an independent variable (Guba & Lincoln, 1989, p. 234). In other words, the validity depends on whether you have evidence that what you did in the study caused what you observed to happen. Cohen et al. (2000) associate internal validity with “accuracy” (p. 107). They explained that the “findings must accurately describe the phenomena being researched” (p. 107). In this regard, the main concern of the researcher in this study was not to attempt to demonstrate absolute accuracy of the findings, but to provide accuracy of the interview protocols used to collect data so that the findings would accurately depict the purpose. As explained before, the content validity of the two interview protocols for Case Study 1 and Case Study 2 were determined initially by several experts before they were piloted.

External validity, on the other hand, involves generalization. It is concerned with the truthfulness of the findings across different persons in other places and at other times (Guba & Lincoln, 1989). In this study, one major approach to ensuring external validity was a process of crosschecking with previously reported research findings.

4.9.1.2 Reliability

Reliability is the “consistency of a given inquiry and is typically a precondition for validity, because a study that is unreliable cannot posses validity” (Guba & Lincoln, 1989, p. 234). More simply, reliability is the consistency of any measurement. It is normally expressed in terms of statistics. There are four approaches to computing reliability coefficients in general use; test-retest, alternate forms, split-half and internal consistency (Burns, 2000). Reliability coefficients are expressed as a number between 0.1 and 1.0. The higher the coefficient suggests the higher level of reliability. Since this study involves only one administration of an instrument, the internal consistency method was used to estimate the reliability coefficient. The particular index used was the Cronbach’s coefficient alpha. The reliability of this part of the study is estimated and explained in detail in the next chapter that presents the Pilot Study.
4.9.2 Qualitative data

Lincoln and Guba (1985) proposed 'trustworthiness' as the parallel term of 'rigour' for the qualitative paradigm. Likewise, the terminologies of reliability and validity from the quantitative paradigm have been replaced by credibility, transferability, dependability and confirmability in the qualitative paradigm (Lincoln & Guba, 1985).

4.9.2.1 Credibility

Guba and Lincoln (1989) suggest that internal validity in rigour is parallel to the standard of credibility in trustworthiness. Guba and Lincoln (1989) and Merriam (1998) recommend several techniques for enhancing credibility. The credibility of this study was enhanced by emphasizing rapport between the researcher and the participants including teachers and pupils. This was initiated through prolonged engagement (Guba & Lincoln, 1989) at the two schools and using data collection techniques, like note taking rather than video, that are less threatening in the classroom. Merriam (1998) and Guba and Lincoln (1989) suggest that sharing the information and findings with peers can contribute to the credibility of the research. In this study, colleagues from the same research team were often engaged in discussions of new findings. Moreover, findings have been rigorously reviewed and presented to the science education community at two international conferences (Salleh, Venville & Treagust, 2003a; 2003b). The design and implementation of the interview protocols was initially an iterative process that involved several science education colleagues, trials with students and improvement (Guba & Lincoln, 1989).

To clarify meaning and verify the repeatability of an observation or interpretation, this study employed triangulation at several levels (Merriam, 1998; Stake, 1998). Patton (1990) describes four levels of triangulation; methods triangulation, triangulation of sources, analyst triangulation and theory and perspective triangulation. Method triangulation was employed in this study through the use of both interviews and classroom observations. These strategies are described in more detail earlier in this chapter. In a similar sense, triangulation of sources was included because data was collected from individual students through interview and from the collective body of students through observation. Furthermore, students'
understanding of two clusters of science concepts was triangulated to answer the primary research question about the influence of language transition on students' science understanding.

To further enhance trustworthiness, theory triangulation (Patton, 1990), that is, the use of multiple theoretical perspectives to analyse the data, was a cornerstone of this research. Children's understanding of science was interpreted from several perspectives including epistemological and ontological perspectives of conceptual change, a developmental perspective and a language perspective.

4.9.2.2 Transferability

Transferability was proposed as a parallel to external validity for the qualitative paradigm (Guba & Lincoln, 1989). However, while generalization is based on the conditions for randomized sampling, transferability refers to the process of "checking the degree of similarity between sending and receiving contexts" (Guba & Lincoln, 1989, p. 241). The transferability criterion is satisfied, according to Lincoln and Guba (1985), by "thick description" (p. 328). Merriam (1998) defines thick description as "the complete, literal description of the incident or entity being investigated" (p. 29–30). By providing a thick description of a particular situation, the events and situations are thus allowed to speak for themselves (Cohen et al., 2000) and the reader can make decisions about the degree to which the findings can be transferred to another context. Transferability in this study was strengthened by using a series of cases and providing rich qualitative data.

4.9.2.3 Dependability and confirmability

Is the data stable over time? Guba and Lincoln (1989) suggest that instability may occur "because inquirers are bored, are exhausted, or are under considerable psychological stress from the intensity of the process" (p. 242). This, however, does not include changes that occur as a result of methods reconstruction (Guba & Lincoln, 1989). In this regard, dependability of this study was enhanced by having only one researcher collect data. This ensured that the data collector was critically aware of the purpose and importance of the data throughout the data collection process.
The major technique for establishing confirmability is the confirmability audit (Lincoln & Guba, 1985). This is achieved by using an audit trail as a way of cross-checking and confirming the findings. Morse, Barrett, Mayan, Olson and Spiers (2002) however, argued that “an audit trail is of little use for identifying or justifying actual shortcomings that have impaired reliability and validity. Thus they can neither be used to guide the research process nor to ensure an excellent product, but only to document the course of development of the completed analysis” (p. 7). While it may not be a suitable verification strategy according to Morse et al., in this study, the researcher has presented the findings so that data can be tracked to the source (Guba & Lincoln, 1989).

4.10 Ethical Issues

It is unethical in terms of human relationships to conduct an investigation when the subjects are unaware of the real purpose (Burn, 2000). Patton (1990) points out that “the purpose of a research interview is first and foremost to gather data, not change people” (p. 354). He further explains that the interviewer is not “a cold slab of granite- unresponsive to the human issues, including great suffering and pain, that may unfold during an interview” (p. 354). Even though the data collected for this thesis were not politically, socially or physically sensitive in nature, ethical issues were considered important as Stake (1998) suggests that “their (qualitative researchers) manners should be good and their code of ethics strict” (p. 103). An important aspect of the data collection process was the researcher-participant relationship during interviewing and classroom observation. The nature of the cultural context of Brunei, however, meant that the researcher was limited in the kind of relationships that she could develop with the participants. Therefore, the most important ethical issues related to this study concerned the teachers, the school children and the school where the investigations were conducted. The ethical issues taken into consideration during the development of this research thesis were: informed consent, access and acceptance, anonymity and confidentiality (Cohen et al., 2000). These will be elaborated in the following paragraphs.
4.10.1 Informed consent

Burns (2000) asserts that the principle of informed consent is the most important ethical agenda in doing research. It involves the right to participate and the right to refuse to take part (Cohen et al., 2000). The researcher was fully aware that in democratic countries, like Australia, participants must first give their consent before participating in any research activities. Potential participants should sign an informed consent form which describes the purpose of the research and the right to withdraw (Burns, 2000). In Brunei, however, this is not the natural or acceptable course of events.

By being given permission from the Brunei Ministry of Education, teachers were required to participate in the study as part of their teaching duties. The school children also were no exception. In Brunei, once the education authority has granted permission, there is no need for the Ministry, the School or the researcher to inform parents or to get parental permission. Regardless of this, the investigation was conducted in an ethical manner. Prior to data collection, the teachers and children were fully informed about the purpose of the research. They were given adequate warning that the researcher was coming to the class on a particular schedule. It also was emphasized to children that no marks would be given for their answers and that the interviews were not a test. The children and the teachers also were told that they were to participate without feeling coerced and were free to withdraw from participation at any time (Burns, 2000). For Case Study 1, all children selected decided to participate. For Case Study 2, two children opted not to. The children’s choice was respected and the researcher found two other children to replace them. Thus, even though the participants in this study did not have to sign a consent form, the researcher did her best to make the situation clear and to have participants who were informed and consented to take part.

4.10.2 Access and acceptance

"Investigators cannot expect access to a nursery, school, college, or factory as a matter of right" (Cohen et al., 2000, p. 53), even though the participants are school children and parental permission is not required in Brunei. In fact, getting
permission from the relevant authority in the Ministry of Education was the biggest single event in the whole procedure of data collection for this study.

As soon as the research project proposal was approved by the Curtin University Board of Graduate Studies, the process of getting access to the schools began. The first stage involved contacting the principals in the respective schools and informing them about the nature of the research to be conducted. In establishing rapport, the researcher also spoke to the teachers who would be participating in the investigation. This was followed by requesting permission formally, in writing, through the official channels. A letter was sent to the Ministry of Education, in particular the Primary Education Section, explaining in detail the purpose of the study and the data collection methods to be used.

As soon as the permission was obtained, a series of visits were made to the schools during which arrangements were made with the teachers whose children and classes were to be involved in the interviews and observations. Permission also was sought from the respective teachers in each school to use appropriate rooms to conduct the interviews.

4.10.3 Anonymity and confidentiality

According to Cohen et al. (2000), anonymity ensures that information provided by participants does not reveal their identity. The personal data of the children interviewed and the teachers observed in this study have been presented in an anonymous way. Another way of protecting a participant’s right to privacy was through the promise of confidentiality (Cohen et al., 2000, p. 62). Confidentiality was considered important in this thesis because the disclosure of information about the teaching and learning that was happening in the classrooms might result in the teachers’ incompetence in both science teaching strategies and English language acquisition being revealed. This could result in embarrassment. A number of techniques were included to ensure anonymity and confidentiality of the findings. The use of pseudonyms, instead of the participants’ real names, means that people other than the researcher cannot identify the participants from the information presented in this thesis. The locations of the schools also were concealed. Total anonymity was, however, not possible because after the analysis of the initial data,
the researcher revisited some of the children whose explanations needed further exploration. For this purpose, the names of students were linked with the initial data, however, this information was only available to the researcher. Raw data were stored in a locked drawer and only the researcher had access to it. Finally, to reduce the possibility of losing confidentiality through the involvement of many interviewers (Patton, 1990), data in this study were collected only by the researcher.

4.11 Summary

The planning of educational research is not an arbitrary matter. Rather, the selection of methodologies depends largely on the notion of 'fitness for purpose' (Cohen et al, 2000, p. 135). This chapter has clearly demonstrated the suitability of the selected methods to address the purpose of the study by aligning each research question with data source, instrument, data collection strategies and analysis. The primary research paradigm in which this study is situated is qualitative. For the purpose of interpretation, however, data were coded and analyzed quantitatively and later scrutinized qualitatively.

This chapter expanded on the construction and development of the interview instruments used for data collection. As with other research methods, instruments in case studies are beset by issues of validity and reliability. The qualitative and quantitative analyses that were used in this study called for a dual system of rigour and trustworthiness drawn from both paradigms. The information to be offered through the instruments from the participants should present the researcher with an insight into real impressions of the children's science concepts. In order to ascertain whether this was the case with the newly developed instruments, two pilot studies were conducted. The following chapter presents and discusses these pilot studies as a method of enhancing validity, reliability and trustworthiness of the forced-response and semi-structured interview questions for both Case Studies 1 and 2.
CHAPTER FIVE

PILOT STUDY

5.0 Introduction

Developing appropriate research instruments in the form of interview protocols was an important activity in the initial stages of this research. This process required the consideration of content, appropriateness for age level and aspects of conceptual change theoretical models. Two interview protocols, one for each of the two clusters of concepts investigated, were developed and described in the previous chapter. Pilot studies were undertaken prior to the main data collection in order to verify the validity and reliability of the interview protocols and improve questions, wording, sequence, format and the scales. The pilot studies are explained in two separate sections in this chapter, Pilot Study 1 for the interview protocol used for exploring children’s understanding of evaporation and condensation and Pilot Study 2 for the interview protocol used for exploring children’s understanding of living and non-living things.

5.1 Pilot Study 1: Interview Protocols about Evaporation and Condensation

Pilot Study 1 was undertaken in June 2001 in one primary school in Brunei in order to trial the interview protocol about evaporation and condensation. Sixty children, aged between 6 and 10 years of age, were randomly chosen from three Primary levels 1, 3 and 4, 20 children from each level. The school was purposefully selected for this pilot study (Patton, 1990) because it was located near School A where Case Study 1 was to be conducted. This allowed the researcher to anticipate the outcomes of the responses because the social, economic and educational status of the children in the two schools were similar. Moreover, the children were expected to have comparable experiences of daily phenomena related to science concepts such as evaporation and condensation, used a similar Malay dialect for conversation and had similar experiences with English language in the early years of school. The size of
the pilot study school also was comparable with school A. Thus, as far as school management and facilities were concerned, the principals, as well as the teachers, were likely to encounter similar administrative and teaching loads. Finally, this school also had children with mixed attainment levels accommodated in the same class.

The general approach to the pilot study was based on the use of an interview protocol which consisted of two main sections. The first section included semi-structured interview questions and the second section included forced-response interview questions. Two sets of interview protocols were drafted, one for the lower primary level and the other for the upper primary level. The rationales for having two different sets of interview protocols were discussed earlier in Chapter 4. All the children were interviewed in groups of 3. All interviews were carried out in the reading corner of the children’s classrooms during regular lessons.

Each child’s response to each question on the interview protocol was written down by the researcher on a response sheet. For Primary 1 and 3 children, all questions and statements were asked and read in Malay. Primary 4 children, on the other hand, were interviewed in English. If the children were unable to understand the questions, however, the researcher would try to explain in Malay. Two separate sets of data were thus obtained. First, all Primary 1, 3 and 4 children’s responses were accepted and analyzed regardless of the language they used, and second, Primary 1 and 3 children’s responses in Malay were accepted but only English responses were accepted and analyzed for Primary 4. The whole interview process took approximately 30 minutes for each group.

As explained earlier in Chapter 4, the participants were to select a response from 5-choice answers for the forced-response interview questions. The 5 responses that they could choose were ‘strongly agree’, ‘agree’, ‘disagree’, ‘strongly disagree’ and ‘I don’t know’. A rating of 5 indicated strong agreement with the statement while a rating of 2 indicated strong disagreement. The response ‘I don’t know’ was rated 1. For the children’s responses on the forced-response interview questions, the researcher simply put a tick on the scale that the child chose. The researcher read the sentence to a child and asked what he or she thought of the statement. For example,
the researcher said that “a human being is alive”. If the child thought that he or she ‘strongly agreed’ that human beings are alive, the researcher would circle 5.

5.1.1 Piloting the semi-structured interview questions

During the pilot study of the semi-structured interview questions, children’s verbal conceptions and explanations on four evaporation and condensation scenarios were explored. The main questions explored as mentioned earlier in Chapter 4 were:

- What is happening to the puddles of water one hour after the rain? Why?
- What is happening to the wet clothes as they are hung under the sun? Why?
- Water in a dish left under the sun disappears. Why?
- Describe the picture of the water cycle.

The children’s verbal responses were first sorted and coded based on the coding shown in Table 4.12 in Chapter 4. Scores were later awarded to the kind of explanation given (also Table 4.12). The mean for all the responses from Primary 1, 3 and 4 children were calculated and plotted.

Figure 5.1 shows the pattern of children’s understanding about evaporation and condensation when Primary 4 children’s responses in Malay were analyzed. This pattern shows that children at increasing primary levels demonstrated a shift from naive towards more sophisticated conceptions about the concepts. From these results, it can be concluded that this instrument demonstrated validity as the data was consistent with other studies (Bar, 1989; Bar & Galili, 1994; Tytler, 2000).

However, when only English responses were accepted and analyzed for Primary 4 children, as shown in Figure 5.2, the pattern of children’s development of understanding was inconsistent with trends documented in the literature (Bar, 1989, Bar & Galili, 1994; Tytler, 2000; Tytler & Peterson, 2000b). The questions used in the semi-structured interview section were mainly adapted from Tytler’s (2000) material. They were considered appropriate for documenting patterns of conceptual understanding about evaporation and condensation for Brunei primary children from Primary 1 to 4.
**Figure 5.1** Mean scores of children on the semi-structured interview questions with both Malay and English responses in the Pilot Study 1.

**Figure 5.2** Mean scores of children on the semi-structured interview questions with only English responses in Primary 4 in Pilot Study 1.
5.1.2 Piloting the forced-response interview questions

Unlike the ideas presented in the semi-structured interview questions, the forced-response interview questions were not developed from established research. To ensure the validity and reliability of these questions, they were piloted with a group of 60 children, 20 from each level of Primary 1, 3 and 4. For Primary 4 children, questions were read and they were asked to respond in English. Marks were awarded to the children based on the rating of the scale they chose as the most appropriate to reflect their level of agreement with the statements. The total mean scores of the children in the respective primary level were then calculated and plotted.

Figure 5.3 shows that the total mean scores for the children on the forced-response interview questions ‘dropped’ in Primary 4. This pattern of development reflected the findings observed in the children’s responses to the semi-structured interview questions when only English responses were accepted for Primary 4.

This pilot study also was conducted to test for reliability, readability and the effectiveness of the interviewing procedures. The readability of the questionnaire was verified. The reliability on the forced-response section was calculated. Burns (2000) explains that the 'perfect reliability' value is +1.0, that is, when there is no error component. Feedback revealed that the Cronbach’s alpha for the forced-response interview questions was .73, .71 and .74 for Primary 1, 3 and 4 respectively. With reliability coefficients from .71 to .74, it was concluded that the forced-response interview questions section provide stable, accurate and dependable data. This demonstrated that the forced-response interview questions were sufficiently internally consistent to be adopted in the main data collection process. The items were rewritten with minor changes, however. For example, the word ‘sidewalks’ was replaced by ‘roads’ because of its suitability in the Brunei context. The item ‘We drink water from the rain’ was thought to be confusing and changed to ‘We drink water which comes from the rain’. One item from this section was deleted because no children were able to respond in an appropriate way and it was considered too difficult. The item was, ‘Evaporation is the changing of a liquid into vapour’.
**Figure 5.3** Mean of children’s total scores on the forced-response interview questions in Pilot Study 1.

### 5.1.3 Conclusions from Pilot Study 1

The main result obtained in Pilot Study 1 was that the results roughly supported the hypothesis that the conceptual development of the children about the concepts of evaporation and condensation from Primary 1 to 4 was negatively affected when the language of instruction is changed from Malay to English. Ideally, children should progress from naïve towards more sophisticated, generalized conceptions over the primary school years (Tytler, 1997), in an ideal pattern shown in Figure 5.1.

The process of piloting the interview protocol also indicated that interviewing the children in their classrooms was not advisable. The researcher found it difficult to compete with the voice of the teacher while teaching took place, and interviews were frequently interrupted by the interviewee’s friends when, from time to time, they came near the reading corner and listened to the conversations between the researcher and the children being interviewed. The children were, therefore, interviewed in the resource room for the main data collection.
5.2 Pilot Study 2: Interview Protocols about Living and Non-Living

In Pilot Study 2, an instrument was developed to determine children’s understanding of the cluster of concepts associate with living and non-living. This study involved a wider range of classes up to the Primary 6 level. As this topic is taught formally at school, the researcher felt that it would be interesting to find out what would happen to the development of children’s understanding about living things as they are given more opportunity for learning the English language at the Primary 5 and Primary 6 levels. Based on the teachers’ experience and records, 5 children were selected from each primary level to represent the groups of high achievers, average achievers and low achievers. The ages ranged between 6 and 11 years of age. The main approach for data collection was again based on the use of an interview protocol, which consisted of both semi-structured interview questions and forced-response interview questions. However, unlike the interview protocol for Pilot Study 1, all the questions in the interview protocol for Pilot Study 2 were the same for all primary levels. As in Pilot Study 1, all the children were interviewed in groups of 3. However, based on experience in the first pilot study, all interviews were carried out in a resource room, rather than the classroom.

As in Pilot Study 1, the school selected for Pilot Study 2 was located near School B where Case Study 2 was to be conducted. What was important in this pilot study was that the children in both schools used a similar dialect for conversation and had a comparatively similar living environment to ensure similar experiences and exposure to living and non-living things. The size of this school was similar, hence teachers and administrators had similar teaching workloads and other duties. Finally, this school also had children with mixed attainment levels present in each class, similar to the school where Case Study 2 was later conducted.

5.2.1 Piloting the semi-structured interview questions

In this pilot study, children were asked to respond to a list of interview questions shown in Table 4.9 (Chapter 4) which were adapted from Venville’s (2004) material. These questions were first crosschecked with the Brunei curriculum in order to document when such topics were taught.
The first draft of the semi-structured interview questions was pre-piloted with 6 relatives' and friends' children, after which they were modified and amended. The result of this exercise led to the alteration of the question sequence. Thus, instead of asking the children 'Do you know what living means?' and 'What does it mean?' at the very beginning of the interview, these questions were asked after the children named some things they thought are living and not living. This was to provide the children with a greater opportunity to discuss examples of living things before having to explain their understanding of the word itself. The revised version of the interview protocol was then piloted with a total of 25 children from Primary 1, 3, 4, 5 and 6.

All the children who participated in the interviews managed to provide the data necessary for the researcher to identify their naïve conceptions and to detect a general pattern of development of understanding about living. Living thing was the concept used by Carey (1985) to capture the different ontological ideas between children and adults. Carey showed that young children consider plants not to be alive, and that only by the age of 10 do children categorize animal and plant in a single ontological type, living thing. Accordingly, the younger children in this pilot study did not recognize plants as living things. By the age of 10, the Primary 5 children tended to display the adult pattern of response because they considered plants as living things.

In order to explore the patterns in the children's understanding of living and non-living, their descriptions of the characteristics of living things were analyzed. Marks were awarded to children who used scientifically acceptable criteria to identify living things. For example, the criteria of 'movement', 'growth', and 'nutrition', were given 1 mark each. Two marks were given for each of 'breathing', 'reproduction' and 'excretion', because these characteristics were thought to be more abstract than the first set of characteristics. The characteristic of 'irritability' or 'response', which was thought to be the most sophisticated attribute of living things, was awarded 3 marks. Marks were calculated and plotted.

The results of this analysis (Figure 5.4) indicate there was a consistent pattern of development of understanding about the concepts of living and non-living for the children from Primary 1 to 5. For this data, only English responses were accepted
from Primary 4 onwards. An unexpected result, however, was observed for Primary 6 where the children's understanding did not progress in the projected manner. This was surprising because Primary 6 is not affected when the language of instruction is changed.

The results of this exercise indicate two possible points for further consideration. First, the results obtained from this instrument were consistent with previous studies (Carey, 1985) and second, the development of children's conceptual understanding of the concepts of living and non-living may not be affected by the change of language of instruction. Indeed, this contrast with the results of the first pilot study on evaporation and condensation makes this second aspect of the study interesting.

![Chart showing mean scores for Primary levels](image)

**Figure 5.4** Children's mean scores from the semi-structured interview questions about the characteristics of living with only English responses from Primary 4 onwards in Pilot Study 2.

5.2.2 Piloting the forced-response interview questions

The forced-response interview questions on living and non-living things were piloted with 25 children. For lower primary children, items were read in Malay. For
the upper primary, items were read in English. Marks were awarded to the children based on the rating of the scales they chose as the most appropriate level of agreement with the statements read to them. The mean scores were calculated and plotted.

The results from the forced-response interview questions show that there is a consistent pattern of development of understanding from Primary 1 to 5 (Figure 5.5). The mean score for Primary 6 children dropped to a level lower than Primary 1 which was consistent with the pilot of the semi-structured interview questions. At this level (Primary 6), the children have already been exposed to English as the language of instruction for almost 3 years and this observed effect is unlikely to be associated with the change in the language of instruction.

During the pilot of the interview protocol, children commented that they were either confused or did not understand some of the 26 forced-response items. In addition, it took the researcher almost 1 hour to read and explain the items to each child. It was doubtful, therefore, that in the main data collection the children could sustain their concentration when answering such a lengthy interview. The number of questions was, therefore, scaled down from 26 to 23 and some items were rephrased. For example, 'plants can respond to changes around them' was changed to 'plants can protect themselves' and 'animals are different in the way they breed' was changed to 'animals produce young in different ways'. Examples of items that were removed were 'all living things give off waste', 'plants are sensitive to light and animals are sensitive to many things such as noise', and 'plants are living things but they move, take in food, produce energy, grow, reproduce, excrete and react to changes in quite different ways'.

The forced-response interview questions section yielded an internal consistency of the Cronbach's alpha of .82, .23, .84, .70 and .86 for Primary 1, 3, 4, 5 and 6 respectively. There was a strong degree of similarity and consistency for Primary 1, 4, 5 and 6 children. The .23 Cronbach's alpha score for Primary 3 children was unexpected and very different from the other primary level scores. This may simply reflect a sampling variation due to individual differences in the children. This unusual score was unlikely to be the result of faulty items given the consistency between the other primary levels. Burns (2000) also reveals that there are a number
of factors that may influence the reliability of any test. These include, factors dealing with the nature of the test questions, the nature of the students being tested and factors related to the administration of the test. Since the reliability coefficients for children in Primary 1, 4, 5 and 6 were close to +1.0, or the perfect reliability, it can be assumed that the low reliability coefficient for Primary 3 children was because of the nature of the children themselves and not the test. This assumption helps to verify that the questions for the forced-response interview section were sufficiently internally consistent to be adopted in Case Study 2.

![Mean of children's total scores](image)

**Primary level**

*Figure 5.5* Children's mean scores on forced-response interview questions about living and non-living.

5.2.3 Conclusions from Pilot Study 2

The main outcome of this second pilot study was that the interview protocol demonstrated validity and reliability, thus suggesting its suitability for data collection in Case Study 2. However, the piloting of the interview protocol on living and non-living things confirmed the difficulty of having group interviews. When one child presented his or her idea about the question posed, other children often simply
copied the answer. It was difficult, therefore, for the researcher to distinguish the real conceptions held by the individual children about the concepts of living and non-living. In order to ensure the authenticity of the data, it was decided that the children would be interviewed individually in the main data collection phase.

5.3 Summary

A great deal of time and effort was invested during the first stage of this research for developing valid and reliable interview protocols. This process, however, does not ensure the questions' clarity and relevance for the sample population selected for the main data collection phase. Furthermore, the uniqueness of each education context may result in instruments even from well-established research not demonstrating reliability and validity. This chapter has shown that, as a result of the pilot testing, the interview protocols needed to be modified and the procedure of administering interviews had to be revised to suit the context in which data was to be collected. The intensive interview process in the pilot study was a very important experience for the researcher because it allowed her to sharpen her interview techniques and skills and, at the same time, estimate how long each interview session in the main data collection phase would take to complete. Having revised some of the questions and cut them down to a manageable number so that only questions strictly relevant to the research questions would be included, data collection for Case Studies 1 and 2 began. The following three chapters present the analysis and discussion of data for Case Study 1 and Case Study 2. The chapters are presented in a manner consistent with the progression of the research questions which are presented on pages 4 and 5.

As these research questions are about two different clusters of science concepts, the results will be presented in two separate sections; two chapters on children's understanding of evaporation and condensation (Chapters 6 and 7) and one chapter on children's understanding of living things (Chapter 8).
CHAPTER SIX

CHILDREN’S UNDERSTANDING OF EVAPORATION AND CONDENSATION: AN ANALYSIS FROM A DEVELOPMENTAL PERSPECTIVE

6.0 Introduction

This chapter is the first of three chapters in which the findings of this study are presented and discussed. The goal of this chapter is to discuss Brunei children’s understanding of the science concepts of evaporation and condensation from a developmental perspective. The first three research questions, 1a, 1b and 1c, were formulated to guide this part of the investigation and each of these questions is addressed sequentially in this chapter. Initially, Brunei children’s naïve conceptions of evaporation and condensation are considered through their responses to semi-structured interview questions on four scenarios about a puddle of water, drying clothes, water in a dish and a picture of the water cycle. The patterns of development about this cluster of concepts are then investigated through the quantitative analysis of the semi-structured and forced-response items. These patterns are then exemplified with excerpts from transcripts of interviews with the children. Finally, the data are analysed by gender in order to compare girls’ and boys’ development of understanding about these concepts.

6.1 Research Question 1a:

What are Brunei children’s naïve conceptions about evaporation and condensation?

This research question was answered by considering and analyzing primary children’s responses on questions about four evaporation and condensation scenarios in the semi-structured interview questions presented earlier in Chapter 4, p. 86. For the purpose of recounting children’s naïve conceptions about these concepts, children’s responses in both Malay and English were accepted. The children’s
responses to the questions will be presented in the next four sections. The fifth section presents the combined data from scenarios 1 to 3.

6.1.1 Findings

6.1.1.1 Scenario 1: What would happen to the puddle of water, one hour after the rain? Why?

When the children were asked to provide explanations of the puddle of water scenario, the majority responded with very basic descriptions of this phenomenon. The most common explanations for the evaporation of water from a puddle were; “water goes to the earth or goes down holes or drains” (25.5%) and “the sun heats the water” (18.3%) (Table 6.1). These explanations are perceptual because they simply describe what the child sees or experiences. Other explanations were; “water just dries by itself” (3.8%), “the rain stops” (6.6%) and “water goes up to the sky” (3.3%). Forty-eight children (26.6%) gave either no response or meaningless opinions regarding the process (Table 6.1).

The number of participants giving the relatively simple perceptual explanation that “water goes to earth or goes down holes or drains” decreased as the primary level increased. Only 10 Primary 4 children, compared with 21 Primary 1 children, gave this explanation. The reverse occurred with the more sophisticated idea that “the sun heats the water” with 28 Primary 4 children and only 1 Primary 1 child giving this response. None of the Primary 4 children used the explanation that “water goes up to the sky”, but there was a prominent group of Primary 4 participants who said that “the water is being heated by the sun”. Even though they were not able to explain why and how the amount of water decreases by virtue of the sun heating the water, 3 Primary 4 children said that “the sun ‘absorbs’ the water”. Ideas that could be classified as misconceptions included “water dries by itself” or “water just disappears”. Explanations such as “rains stop” and “water remains in the puddles because water is too deep and it is still raining” were classified as neither misconceptions nor ‘scientific’ explanations.
Table 6.1 Number of children giving various explanations of the first scenario: One hour after rain, what would happen to the puddle of water? Why?

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1 n = 60</th>
<th>Primary 3 n = 60</th>
<th>Primary 4 n = 60</th>
<th>Total n = 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry by itself/ water just disappears</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Rain stops</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Water goes to earth / goes down holes/</td>
<td>21</td>
<td>15</td>
<td>10</td>
<td>46 (25.5%)</td>
</tr>
<tr>
<td>drains</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water goes up to the sky</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Sun heats the water</td>
<td>1</td>
<td>4</td>
<td>28</td>
<td>33 (18.3%)</td>
</tr>
<tr>
<td>Sun 'absorbs' the water</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Water remains in the puddles because</td>
<td>9</td>
<td>12</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>water is too deep and it is still raining, etc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No answer</td>
<td>21</td>
<td>19</td>
<td>8</td>
<td>48 (26.6%)</td>
</tr>
</tbody>
</table>

6.1.1.2 Scenario 2: What is happening to the wet clothes as they are hung under the sun? Why?

Table 6.2 shows that about 92.7% of the children interviewed attempted to give an explanation of the scenario of the drying of wet clothes. The high response rate was probably due to this activity being the most common everyday experience of the four scenarios. About 75%, or the vast majority of children, said that "the sun heats and dries the clothes". The increase in the number of children giving this explanation was dramatic, particularly between Primary 1 and Primary 3. Three Primary 4 children provided a more complicated explanation for the phenomenon, that "the sun 'moves' or 'absorbs' the water from the wet clothes". Even though these children could not articulate a sophisticated scientific explanation for this scenario, these explanations had required some thought. None of the Primary 4 children gave simple and/or perceptual explanations such as "clothes become dry because they are hanging and hot", that were more popular with the younger children. Only one interviewee said that "water changes to steam" and, interestingly, that child was in Primary 3 and not in Primary 4 as would be expected. The following excerpt is from that child's interview:
Interviewer: Apakah yang akan terjadi pada pakaian-pakaian tadi selepas beberapa jam?
(What would happen to the clothes after a few hours?)

Child: Pakaian-pakaian itu telah kering.
(The clothes would become dry.)

Interviewer: Kenapa kamu fikir ia akan terjadi sedemikian?
(Why do you think so?)

Child: Cahaya matahari membuat air dari dalam baju atu jadi wap.
Lapas tu naik tia (wap) keatas.
(The sun changes the water in the clothes to become steam.
The steam later goes up.)

Table 6.2 Number of participants giving various explanations of the second scenario: What is happening to the wet clothes as they are hung under the sun? Why?

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1</th>
<th>Primary 3</th>
<th>Primary 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 60</td>
<td>n = 60</td>
<td>n = 60</td>
<td>n = 180</td>
</tr>
<tr>
<td>Dry by itself</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Clothes become dry because they are hanging and hot</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Water goes down</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sky warms the clothes</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Clouds warm the clothes</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Sun heats and dries the clothes</td>
<td>30</td>
<td>51</td>
<td>54</td>
<td>135 (75%)</td>
</tr>
<tr>
<td>Sun 'moves' the water</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sun 'absorbs' the water</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Water changes to steam</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No answer</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>13</td>
</tr>
</tbody>
</table>

As identified earlier, the most popular explanation for the scenario of the drying of wet clothes was “the sun heats and dries the clothes”. This kind of explanation was categorized as a preliminary (pseudo) scientific conception because there is little scientific knowledge conveyed, however, they are not scientifically incorrect. The
naive explanations including “water dries by itself”, “the sky warms the clothes”, “clouds warm the clothes”, “sun moves the water” and “sun absorbs the water” were classified as misconceptions because they have no scientific basis. Twenty-two children (12.2%) were shown to have these misconceptions. Only 5% of the children used purely perceptual explanations that did not provide any indications of scientific misunderstandings including “clothes become dry because they are hanging and hot” and “water goes down”. Overall, the results indicate that Brunei children’s thoughts about the drying of wet clothes are largely influenced by their pseudo-scientific knowledge.

6.1.1.3 Scenario 3: Water in a dish left under the sun disappears. Why does this happen?

For the water in the dish scenario, 72.2% of the children gave the reason that the sun warms and dries the water as an explanation of why the water disappears (Table 6.3). Only one Primary 4 child said that “the sun ‘absorbs’ the water”. Unexpectedly, there also was one Primary 1 child who attempted an explanation that “water is being ‘absorbed’ by the sun”. It is uncommon for young children to observe water disappearing from a dish unless the observation is encouraged by teachers or parents. This could be the reason why almost one-third of the sample population gave no response to this question.

Table 6.3 Number of participants giving various explanations for the third scenario: Water in a dish left under the sun disappears. Why does this happen?

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1 n = 60</th>
<th>Primary 3 n = 60</th>
<th>Primary 4 n = 60</th>
<th>Total n = 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water dries by itself</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Water goes up</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Moon ‘warms’ the water</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Sun warms and dries the water</td>
<td>29</td>
<td>47</td>
<td>54</td>
<td>130 (72.2%)</td>
</tr>
<tr>
<td>Sun ‘absorbs’ the water</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>No answer</td>
<td>23</td>
<td>13</td>
<td>5</td>
<td>41</td>
</tr>
</tbody>
</table>
Five children (2.7%) provided explanations that indicated misconceptions. For example, "water dries by itself", "the moon warms the water" and "the sun absorbs the water". Four children (2.2%) provided unsophisticated, scientifically correct explanations for the scenario, for example, that "water goes up". The majority (72.2%) of children were shown to have preliminary (pseudo) scientific conceptions of the scenario because they gave the reason that "the sun warms and dries the water". Again, this presented the impression that the children's naïve conceptions were very much influenced by their pseudo-scientific knowledge.

6.1.1.4 Scenario 4: Describe the picture of a water cycle

The frequency distribution of explanations given by the children about the water cycle phenomena is shown in Table 6.4. Three main categories concerning these perceptions included; 1) perceptions that are dominated by cultural beliefs, 2) perceptions that are pseudo-scientific in nature, and 3) perceptions that are scientifically correct.

Table 6.4 Number of participants giving various explanations of the picture of a water cycle.

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1 n = 60</th>
<th>Primary 3 n = 60</th>
<th>Primary 4 n = 60</th>
<th>Total n = 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain comes from the clouds or sky because 'frogs call it' or the clouds are crying</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Blue clouds give water to white clouds</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Rain comes from the sky</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Rain comes from the clouds</td>
<td>24</td>
<td>19</td>
<td>21</td>
<td>64</td>
</tr>
<tr>
<td>Rain comes from the clouds; water from river, sea etc, is being 'absorbed' by the sun</td>
<td>13</td>
<td>0</td>
<td>25</td>
<td>38</td>
</tr>
<tr>
<td>Rain comes from clouds; water from river, sea and ocean goes up</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Water evaporates and forms clouds</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Water is everywhere</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No answer</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>
The statements that pointed to cultural elements that influenced the children's understanding of the water cycle during this part of the interview were: "rain falls because frogs have called it", and "rain falls because clouds are crying". These perceptions reflect the primitive stories used by Brunei elder relatives when they are trying to explain to the young generations how rain forms. It is not clear, however, if they just made up these explanations to satisfy their children or whether they really believed them.

Examples of explanations that fall into the pseudo-scientific knowledge category include; "rain falls when blue clouds give water to the white clouds", and "it rains when sea and river water is being absorbed by the sun and is located in the clouds". These children give a name to a phenomenon, consider that name to name the attribute, for example the movement of water is called 'absorbed', and then explain the occurrence of the phenomenon in terms of the 'existence' of the attribute. These explanations may sound 'scientific' but they are actually not true!

Finally, the explanations that were scientifically correct, but at the same time, not sophisticated included; "rain falls from the sky or clouds", "water in the clouds is formed when sea, river and ocean water goes up", "water evaporates and forms clouds" and "water is everywhere".

Table 6.5 shows that 159 of the 180 children attempted to respond to the question about the water cycle. Only 59.7% of the children who attempted to respond to the question gave a scientific response. However, there were a substantial number of responses (40.2%) in the domains of pseudo-scientific and culturally-based knowledge about the water cycle. The percentages for the response patterns are almost the same as Taiwo's (1999) study with 59.7% and 53% for the scientific responses, and 40.2% and 47% for the pseudo-scientific and culturally based explanations. However, in Taiwo's study, the samples consisted of pupils aged between 9 and 13 years compared with between 6 and 10 years for this study. Based on their overall performance, the children's perception of the water cycle was influenced by scientific knowledge (59.7%). However, the children also brought a significant amount of pseudo-scientific and culturally based knowledge about science-related natural phenomena to school.
### Table 6.5 Response patterns for explanations of the picture of a water cycle.

<table>
<thead>
<tr>
<th>Primary levels</th>
<th>No response</th>
<th>Cultural beliefs</th>
<th>Pseudo-scientific</th>
<th>Scientifically correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 60)</td>
<td>10</td>
<td>2</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>Primary 3 (n = 60)</td>
<td>7</td>
<td>12</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4 (n = 60)</td>
<td>4</td>
<td>0</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td>Total (n = 180)</td>
<td>21</td>
<td>14 (8.8%)</td>
<td>50 (31.4%)</td>
<td>95 (59.7%)</td>
</tr>
</tbody>
</table>

#### 6.1.1.5 Combined analysis of children’s explanations of three scenarios

When all participants’ responses pertaining to the three scenarios of puddles of water, wet clothes and water in a dish are combined, as in Table 6.6, two distinct patterns can be observed. First, the proportion of pupils who claimed that the “sun heats and dries the water” increased dramatically from Primary 1 to Primary 4. Second, the proportion of pupils who claimed that “water goes to earth” decreased dramatically from Primary 1 to Primary 4. The Primary 3 participants tended to give intermediate responses for all scenarios. It could be argued that increasingly complex explanations correlate with an age-related advance for the children, however, there is a substantial overlap between the conceptions used by Primary 1, 3 and 4 pupils.

Bar and Galili (1994), found that the perception that water just disappears is only popular among the younger age groups of children. The results of this study concur with their finding. Bar and Galili also found that the notion that water is absorbed in the ground, or water just simply goes to earth, is a common perception among children between the ages of 7 and 8. In this study, this perception was most frequently expressed by young Bruneian children between the ages of 6 and 7 or when they are in Primary 1. Bar and Galili also found that at ages 7 and 8, children used the explanation that “water ‘evaporates’ or is being transferred to the sky or sun”.

139
This perception was popular with younger children in this study whose ages were between 6 and 7.

Table 6.6 Total numbers of Primary 1 and Primary 4 children giving each kind of response on the three scenarios: water in the puddles, wet clothes and water in a dish.

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1</th>
<th>Primary 3</th>
<th>Primary 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No / irrelevant response</td>
<td>82</td>
<td>56</td>
<td>66</td>
<td>204</td>
</tr>
<tr>
<td>Dry by itself</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Water goes to earth</td>
<td>21</td>
<td>16</td>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td>Water goes to the sky / into air</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Sun heats and dries the water</td>
<td>65</td>
<td>103</td>
<td>107</td>
<td>275</td>
</tr>
<tr>
<td>Sun 'absorbs' the water</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Water changes to steam</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total no. responses</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>540</td>
</tr>
</tbody>
</table>

6.1.2 Conclusions

Bar (1989) described three levels of development for children’s response patterns about evaporation and condensation: 1) primitive or cultural beliefs (ages 5 to 7), 2) pseudo-scientific explanations (ages 7 to about 9), and 3) the idea that water changes into vapour through evaporation is developed by older children. As far as this study is concerned, children aged between 8 and 9 years use cultural belief-based explanations more frequently than the other age groups, whilst the pseudo-scientific explanations were most common among children aged 9 and 10. Only Primary 4 children, mostly aged 9 and 10, expressed the idea that “water evaporates”, however, this was infrequent. While the general pattern of Bar’s explanation of children’s developing understanding about evaporation and condensation is observed in this study, the distribution of age groups is different.

It is interesting to note that the results presented in this chapter show the same proportions of responses from children as Taiwo’s (1999) study. Moreover, the results also reflect Bar and Galili’s (1994) results in terms of the kinds of
conceptions expressed by children of particular primary groups. While Taiwo’s participants were about three years older than the participants in this study when they showed these response patterns, Bar’s (1989) participants were about three years younger. The most significant potential cause for the age difference could lie in the fact that the water cycle phenomena is included in every school curriculum in Israel, the place where Bar did the investigation, but not in Brunei. The rainfall occurrence may not be as common in Israel as in Brunei, but rain in winter is widespread, particularly in Jerusalem, where all Bar’s participants were living.

Taiwo’s (1999) study was conducted in Botswana, a semi-arid country, where drought is a common occurrence. This study was conducted in Brunei where rainfall is a far more common natural phenomenon. The following factors may underlie the substantial earlier development of conceptions in this study’s sample population compared with Taiwo’s participants.

- Earlier encounters with rainfall make the children in Brunei more aware of evaporation and condensation compared with children who have less rainfall experience.

- The instrument used in Taiwo’s study consisted of multiple-choice items. The three choices per item covered aspects of scientific knowledge, pseudo-scientific knowledge and culturally-based knowledge. It is likely that the nature of the multiple choice instrument limited room for the children to express their own explanations.

- The school language of the participants in Taiwo’s study was Setswana, the national language of Botswana. This language may not have a vocabulary and grammar that are suitable for learning such scientific concepts as evaporation and condensation.

- Taiwo’s samples consisted of pupils aged between 9 and 13 years. It is unclear if the response patterns would be the same if the sample had consisted of a younger group of children.

The general pattern of understanding observed in this part of the study correlate with previous studies. However, further investigation showed that the children in each study progressed at different rates. The results also showed that Brunei children
often used pseudo-scientific and culturally-based explanations for the concepts of evaporation and condensation (Table 6.2, Table 6.3 and Table 6.5). This indicates that the children bring significant preconceptions about science-related natural phenomena to school and that their thoughts about science-related phenomena are influenced by culture.

6.2 Research Question 1b:

Is there any indication of a pattern of development of understanding of the concepts of evaporation and condensation from Primary 1 – 4? What impact does language transition have on this pattern of development?

The data that addresses this research question was produced from the analysis of the patterns of responses to the semi-structured questions on the four evaporation and condensation scenarios and by comparing the mean of the children’s total scores on the forced-response interview questions. The following sections will initially consider the qualitative analysis of the semi-structured interview questions followed by some qualitative excerpts from that data. The quantitative analysis of the forced-response questions then follows. The forced-response interview questions comprised ideas which were rarely found in the children’s answers in the semi-structured oral investigation. This aspect of the instrument, therefore, provided greater opportunities to measure children’s understanding of the concepts of evaporation and condensation without having to be concerned about their inability to express explanations in a second language.

6.2.1 Findings

6.2.1.1 Results from the semi-structured interview questions

6.2.1.1.1 Combined analysis of children’s explanations to questions on all four scenarios in the semi-structured interview

As analysis and interpretation of the semi-structured interview data became focused, caution was taken to separate children’s verbal responses into English and Malay to
discern whether the development of the children’s conceptual understanding of the concepts of evaporation and condensation was influenced by language. While the responses from Primary 1 and 3 were given in Malay, responses from Primary 4 were given in either English or Malay. Two separate sets of data were thus obtained from the interviews; first, all Primary 1, 3 and 4 children’s responses were accepted and analyzed regardless of the language they used, and second, Primary 1 and 3 children’s responses in Malay were accepted but only English responses were accepted and analyzed for Primary 4. Both sets of data are presented in this section.

Figure 6.1 shows the development of conceptual understanding by all Primary 1, 3 and 4 children when their responses were accepted and analyzed regardless of the language they used. Figure 6.2 shows the development of the children’s conceptual understanding about the concepts of evaporation and condensation when only English responses were accepted from Primary 4 children.

The patterns evident in Figure 6.1 indicate that at increasing primary levels, children demonstrated a shift from naïve towards more sophisticated conceptions. This finding is broadly consistent with those of previous studies (Bar, 1989; Bar & Galili, 1994; Taiwo, Motswiri & Masese, 1999; Tytler, 2000; Tytler & Peterson, 2000b), which claim that older children expressed a clearer understanding of the concepts of evaporation and condensation compared with the younger children.

Figure 6.2 indicates the pattern of responses when only English responses were accepted for Primary 4 children. As expected, this figure shows that there is a clear shift from Primary 1 to Primary 3 in the children’s understanding from mainly perceptual explanations to more sophisticated explanations such as “water goes into air” for each of the four scenarios. The mean of Primary 4 children’s total scores on all four scenarios, however, dropped to levels lower than Primary 3 and in two scenarios to levels lower than Primary 1. This pattern of development was inconsistent with the expected trend (Bar, 1989; Bar & Galili, 1994; Tytler, 2000; Tytler & Peterson, 2000b). The scenarios about puddles of water and wet clothes provide the most dramatic results. In fact, Scheffe’s tests showed that significant differences lie between the mean for Primary 3 and 4 on both scenarios.
Figure 6.1 Mean scores of children in the semi-structured interviews with both Malay and English responses in Primary 4.

Figure 6.2 Mean scores of children in the semi-structured interview with only English responses in Primary 4.
Children's total scores on all four evaporation and condensation scenarios in the semi-structured interviews were combined, calculated and plotted. Two sets of data were obtained. First, the children's total scores in the semi-structured interviews when their Malay and English responses were accepted and analysed (Table 6.7 and Figure 6.3). Secondly, the children's total scores in the semi-structured interviews when only their English responses in Primary 4 were accepted and analysed (Table 6.8 and Figure 6.4).

Table 6.7 and Figure 6.3 show that there was improvement in understanding, as expected, from Primary 1 to Primary 4 when children's responses to the 4 evaporation and condensation scenarios in both Malay and English were accepted. There was a dramatic drop for Primary 4, however, when their responses were only accepted in English (Table 6.8 and Figure 6.4). It is evident, therefore, that children's expressed understanding of evaporation and condensation was affected by the language of interview.

Table 6.7 Descriptive statistical data by primary level on evaporation and condensation semi-structured interview with Malay and English responses.

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>7.9</td>
<td>2.75</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>9.7</td>
<td>2.75</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>18.9</td>
<td>12.90</td>
</tr>
</tbody>
</table>

Table 6.8 Descriptive statistical data by primary level on evaporation and condensation semi-structured interview with English responses in Primary 4.

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>7.9</td>
<td>2.75</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>9.7</td>
<td>2.75</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>8.0</td>
<td>2.48</td>
</tr>
</tbody>
</table>
Figure 6.3 Mean scores of children for all evaporation and condensation scenarios in the semi-structured interview with both Malay and English responses in Primary 4.

Figure 6.4 Mean scores of children for all evaporation and condensation scenarios in the semi-structured interview with English responses in Primary 4.
6.2.1.1.2 A discussion of the excerpts from the second phase of interviews

When children’s responses in Malay and English in this study were analysed regardless of the language they used, it was found that there was a shift from naïve towards more sophisticated conceptions of evaporation and condensation (Figure 6.1 and Figure 6.3). Two interview excerpts from the second phase of interviews were selected to provide more detailed information about how the patterns of pupil conceptual understanding changed between eight and eleven years of age. The interviews were conducted in Malay. For the purpose of this chapter, the transcribed interviews were translated into English.

Nora, aged 8 (Primary 3), and Udin, aged 11 (Primary 6), were asked ‘what would happen to the (wet) clothes a few hours after they are hung outside under the hot sun?’ They both responded that ‘they would become dry’. Their explanations and elaborations are shown below.

**Pupil 1: Nora (Aged 8)**

Nora’s Malay interview (translated to English):

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>Where does the water go?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nora:</td>
<td>Hm...to the drains, then it goes into the earth.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>But before you said the water also goes to the air.</td>
</tr>
<tr>
<td>Nora:</td>
<td>No, the water only goes into the earth.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>Why do you think so?</td>
</tr>
<tr>
<td>Nora:</td>
<td>I always play with water in the bathroom. The water will go through the holes and disappear. Sometimes the water ‘escapes’ through the door.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>So, there is no water in the air?</td>
</tr>
<tr>
<td>Nora:</td>
<td>Hm...yes there is (still thinking). But I don’t really believe that.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>Are you sure there is no water in the air?</td>
</tr>
<tr>
<td>Nora:</td>
<td>Maybe yes...but I’m only guessing.</td>
</tr>
</tbody>
</table>
Nora's reasoning was purely perceptual because she simply played with her own ideas on how water would eventually disappear based on what she had seen. When asked where the water went, Nora simply thought that water went into the earth. Her ideas were consistent with Russell et al.'s finding (1989) and were coded as explanation Type 2 (perceptual) (Table 4.12).

**Pupil 2: Udin (Aged 11)**

Udin's Malay interview (translated to English):

**Udin:** The water drips to the ground and some goes into the air.

**Interviewer:** Is there any water in the air?

**Udin:** Oh...not water but water vapour. It's water but we cannot see it.

**Interviewer:** How do you know?

**Udin:** We've learnt that in a geography lesson.

**Interviewer:** What happens next?

**Udin:** Water vapour falls down as rain. Water then goes up again to the clouds.

**Interviewer:** What about water in a bowl which is left in a room? Will the water decrease?

**Udin:** No. This time the water will not escape or go into the air. Only when there is sunlight would the water decrease.

**Interviewer:** Em...I see. But what happens to the water on the road during nighttime?

**Udin:** Oh...er.... It will disappear. The road will become dry.

**Interviewer:** Even if there is no sunlight?

**Udin:** Yes....

**Interviewer:** So, water will still become water vapour and escape into the air regardless of whether there is a sun or not! Even in a dark room!

**Udin:** Hmm... Er....yes (hesitate).

Udin, an older child than Nora, was able to reason about evaporation and condensation in a more sophisticated way. At this age, Udin already understood the
basic processes of the water cycle. He could explain that water goes into air or the atmosphere and that water changes to imperceptible forms. Parts of the interview indicate that Udin might not have been confident with his ideas about evaporation. For example, initially he said that sunlight is needed for water to ‘go into the air’. Later he changed his mind, agreeing with the interviewer that a road will dry, even in the dark. Regardless of this hesitancy, Udin used greater precision in language using words such as ‘vapour’, ‘menitik’ (drip) and ‘berkurangan’ (decrease). He also had a surer sense of ontological categories because he used more sophisticated types of responses than simply perceptual. Epistemologically, Udin was able to link his ideas about evaporation and condensation appropriately. Even though he did not mention the word condensation, he realized that water goes up and falls again as rain.

A further important point is that, Udin used the words ‘water vapour’ in English to help him explain the phenomena in Malay. Obviously, he ‘borrowed’ the English words to make his explanations clearer. He explained that he had learnt this idea in a geography lesson and therefore had attended to the learning of this phenomenon in a different way compared with Nora. As a result, Udin was able to make links between related concepts and explain the phenomena at a higher level of sophistication than Nora.

The two interview excerpts also demonstrate the development from a concrete to a more abstract form (Bar, 1989). The explanation provided by Udin demonstrated that the older child had a clearer sense of understanding of the phenomena than the younger child (Tytler, 2000). At one point in the interview, Udin said “...not water but water vapour. It’s water but we cannot see it”. This shows that Udin understood the phenomena in an abstract way. Moreover, it was the accessibility of appropriate words such as ‘water vapour’ (Tytler, 2000) that helped Udin to provide the explanation.

Figure 6.2 and Figure 6.4 show that when Primary 4 children’s English responses only were accepted and analyzed, their expressed understandings about the concepts of evaporation and condensation did not progress as expected. The following excerpts from two children’s interviews in the second phase cast more light on this
situation. Each of the excerpts was selected because the children were fluent in discussing the phenomena when they were asked in Malay.

Pupil 3: Amir (Aged 11)

Amir was a confident child when he was asked to explain the phenomena of the scenarios in Malay. He was asked “what do you think would happen to the wet clothes a few hours after they are hung under the hot sun?” Amir’s responses about evaporation and condensation were considered perceptual because he said that “water will drip to the ground”. He also tried to express his ideas about the water cycle, however they were not very sophisticated because he said that “water goes up to the air...then...to the clouds. When the clouds become black, rain will fall”. What is important is that Amir managed to express his idea fluently when he responded in Malay. Following are excerpts from his interview both in Malay (translated) and English.

Amir’s Malay interview (translated to English):

Amir: The water will drip to the ground.
Interviewer: Will the water also go into the air?
Amir: No.
Interviewer: But, when I asked you before, you said that water goes into the air.
Amir: Er... Hm... oh... yea... maybe..... yes (thinking).
Interviewer: Are you sure?
Amir: Hm... yes! (confident) That is why there are black clouds over there (pointing to the clouds). Water goes up to the air... then... to the clouds. When the clouds become black, rain will fall.
Interviewer: What about a bowl of water which is left in a room? Will the water disappear?
Amir: It will also escape but the water will just go into the floor or the cement.
Interviewer: But....
Amir: That [the water on the wet clothes] happens outside.
Interviewer: That means, water in this room would not escape or go into the air?
Amir: Yes!
Interviewer: But... how would the water go or move down from the bowl?
Amir: Like this.... (trying to explain) ...if the water is in the bowl, then it will still be there (inside the bowl)...hm..... But if the water is spilled on the floor then it will soak in the cement and to the ground.
Interviewer: Will the water in the bowl decrease?
Amir: I don't know....but I think you have to place the bowl outside, because there are clouds there. The water can only escape to the clouds.

Amir’s English interview:

Amir: Explain that in Malay teacher?
Interviewer: Ok...but try to answer me in English.
Amir: I don’t know....
Interviewer: (explained slowly)
Amir: Down.... Under....
Interviewer: What goes down.... and what goes under?
Amir: (Smiling) ...hm...tanah! (ground)
Interviewer: Will the water also go into the air?
Amir: Yes.
Interviewer: What makes you think that there is water in the air?
Amir: In Malay teacher..... what you mean?
Interviewer: How do you know that there is water here (waving through the air)?
Amir: I don’t know... Camana, ada air kah? (How come there is water in the air?)
Interviewer: Yes.
Amir: Ada hujan... (There are rains.)
Interviewer: Where does the rain come from?
Amir: Awan.... (clouds) come from.... from.... Em.... Teacher, awan datang kesini, camana cakap English? (Teacher, how would I say in English [that] clouds fall to the ground?)

Interviewer: Ok.... Never mind. Now, if I put water in a bowl and I place the bowl in this room, will the water in the bowl disappear or decrease after a few days?

Amir: Water timbul (floats)... bukan (No)...the ball timbul (floats) dalam air.

Interviewer: No...No...not ball but bowl (showing a bowl).

Amir: Mangkuk (a bowl)?

Interviewer: Yes.

Amir: Er.... Teacher.... I don’t understand!

Interviewer: Will the water disappear?

Amir: Yes...

Interviewer: What makes it disappear?

Amir: L...(it)...kering...(dries up).

Interviewer: What makes it dry?

Amir: Huh.... What.... I don’t know.

This discourse suggests that, for Amir, English language was the main cause for his inability to provide explanations to the questions asked. Even though his explanation in Malay was not very sophisticated, his English explanation was worse. Not only did Amir hesitate with poor fluency, he seemed to use a very limited English vocabulary and to fill in the gaps in the discussion he frequently used Malay words.

Pupil 4: Mohamad (Aged 11)

Mohamad was another child whose flow of ideas was affected by the change of language. Like Amir, Mohamad was asked “what do you think would happen to the wet clothes a few hours after they are hung under the hot sun?” Mohamad fluently used associations and narrative links in Malay to express his ideas about this scenario. Unfortunately, when asked to explain in English, it became clear that he had a limited English vocabulary. As a result, he hesitated during the expression of his ideas. During the Malay interview, Mohamad mentioned the word ‘wap’ (in
Malay), which refers to both 'steam' and 'vapour'. It was, therefore, not clear, in Malay, if Mohamad meant either steam or vapour. When asked in English, it was found that Mohamad was confused between steam and vapour (Bar & Travis, 1991). Excerpts from his interviews both in Malay (translated) and English are shown below.

Mohamad’s Malay interview (translated to English):

Mohamad: The water will drip to the ground. Some of the water will also go into the air.
Interviewer: What makes you say that?
Mohamad: The water will change into vapour [or steam]. We cannot see it. The vapour [or steam] will go up and into the air. It eventually reaches the clouds. When there is too much water in the clouds, the clouds will become black. Later, there will be rain.
Interviewer: I see, yes...how do you know that?
Mohamad: My father told me.
Interviewer: Do you believe him?
Mohamad: Yes. Last time, when my father brought us to the beach, I saw... vapour [or steam]... The water was hot. My father said, the vapour [or steam] came from the water... The water would change to vapour [or steam] even at night. But during nighttime, the process would be slow because there is no sun.
Interviewer: Are you saying that water in a bowl left in a room will eventually decrease after some time?
Mohamad: Yes... even though there is no sun!

Mohamad’s English interview:

Mohamad: The clothes will be dry after a few minutes.
Interviewer: Few hours?
Mohamad: Er... yes, few hours.
Interviewer: Where would the water go?
Mohamad: To the ground, it will be....it will be..... (tried to find words)...(smiling)
Interviewer: Will the water go into the air?
Mohamad: Yes.
Interviewer: What does happen actually?
Mohamad: The water will ... will ... become rain.
Interviewer: Will the water change to vapour first?
Mohamad: Ha...yes.
Interviewer: Can you see it [the vapour]?
Mohamad: Yes. *(At this instance, it could be assumed that the child was confused between steam and vapour)*
Interviewer: Where will the vapour [or could it be the steam] go?
Mohamad: It will be ... ummm... the rain.
Interviewer: What makes you say that?
Mohamad: My father just told me.
Interviewer: And you believe him...?
Mohamad: Yes.
Interviewer: What about water in a bowl which is left in this room for one night, will the amount of water decrease?
Mohamad: Decrease.
Interviewer: Even if it is not placed directly under the sun?
Mohamad: Yes!

Mohamad's confusion between steam and vapour (Bar & Travis, 1991) did not directly affect his explanation of the phenomena. However, it provided evidence that his vocabulary, and possibly understanding, of these two words was limited. If he had known when to use the two words appropriately, his explanation would have been much better.

Until the advent of the English interview, Amir and Mohamad were confident and expressive with their ideas about evaporation and condensation. They used connecting words (in Malay) to express the logic of their thinking. Both examples show that their competence in the Malay language helped the children to explain the
phenomena fluently. Limited word acquisition, in English, however, demonstrated otherwise. Amir and Mohamad might have had the same understanding of the concepts in their mind whether they were using Malay or English. However, it was difficult to evaluate because they both were shown to have limited access to connecting words in English, fundamental for making their ideas flow. For Amir, the change of language influenced his explanations quite profoundly. As can be seen from the interview transcript, Amir’s understandings of the concepts of evaporation and condensation were already uncertain when he explained the phenomena in Malay. Having to explain the phenomena in English seemed to be an additional and insurmountable complication for him.

It was anticipated that peer and family interactions and school experience would provide opportunities for Brunei children to learn better ideas for explaining the phenomena of ‘water disappearing’. Excerpts from Mohamad’s interview indicated that, even though the concepts of evaporation and condensation are not explicitly taught in the Brunei school curriculum, ‘possible explanations’ were passed from his father. Amir, on the other hand, presented the impression that, as a result of his own rich personal episodes witnessing the phenomena, he managed to develop his own interpretation. Nevertheless, neither Mohamad nor Amir were able to express ideas fluently or confidently in English.

Tytler (2000) mentioned that the ability of the children to explain a phenomenon is largely accredited to context and accessibility in choosing words. When context is not a barrier, it can be assumed that language becomes the main cause for the irregular pattern of the conceptual pathway of children’s understanding. This study seems to support Tytler’s (2000) idea that evidence for conceptual development about the concepts of evaporation and condensation should not only be seen from the age-related or developmental perspective (Bar & Galili, 1994), rather it involves more complex processes. Competence in the language of instruction is one of them.

6.2.1.2 Results from the forced-response interview questions

In order to understand the children’s patterns of development and answer Research Question 1b, the findings from the analysis of children’s responses to the forced-response interview questions as described in Chapter 4, section 4.8.1, are presented
here. The forced-response interview was made up of three sections including questions about water, questions about evaporation and questions about condensation. The following analysis and discussion considers each of these sections separately as well as all the forced-response items together.

6.2.1.2.1 Children’s mean scores on water, evaporation and condensation in the forced-response interview questions

The mean scores on water items increased from Primary 1 (3.86) to Primary 3 (4.24) (Table 6.9). The mean for Primary 4 pupils’ total scores (3.29) however, dropped to levels lower than Primary 3 and Primary 1 (Table 6.9). For the evaporation items, the mean score for Primary 3 dropped to a level lower than Primary 1 before it increased again slightly at Primary 4 (Table 6.9). Finally, for the condensation items, the mean decreased as the primary level escalated. The overall pattern of the means scored by the children in each primary level is shown in Figure 6.5.

If we assume that children’s understanding of concepts such as evaporation, condensation and the water cycle should improve with an increase in age (Bar & Galili, 1994; Taiwo, 1999), then the results presented in Table 6.9 are quite unexpected. The results presented in Table 6.9 show that the mean score for children’s responses about all three concepts of evaporation, condensation and the water cycle were lower in Primary 3 and 4 compared with the mean in Primary 1. The single exception to this was that there was an improvement in mean scores from Primary 1 to Primary 3 on the water items. However, the Primary 4 children, once again, scored lower than the Primary 1 children for these same items.

ANOVA (Table 6.10) showed significant differences in the means for the water and evaporation items, $F(2,177)=39.12$, $p < .005$ and $F(2,177)=3.38$, $p < .005$ respectively. The differences were significant with Cohen’s effect size at 0.47 (medium) and 0.14 (low) for the water and evaporation items respectively. There was no significant difference between the different primary levels for the condensation items. To locate the area(s) of difference, that is, to determine whether the differences exist between or within groups, a post hoc pair-wise comparison analysis using the Scheffe’s tests was carried out (Table 6.11). The results indicate
that the significant differences lie between the following primary levels for the water and evaporation items:

**Water**
- Primary 1 and Primary 3
- Primary 3 and Primary 4
- Primary 1 and Primary 4

**Evaporation**
- Primary 1 and Primary 3

Table 6.9 *Descriptive statistical data of children by primary level on water, evaporation and condensation items in the forced-response section of the interview.*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water items</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.86</td>
<td>0.75</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>4.24</td>
<td>0.33</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>3.29</td>
<td>0.60</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.80</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Evaporation items</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.92</td>
<td>0.95</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>3.52</td>
<td>0.37</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>3.75</td>
<td>1.04</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.73</td>
<td>0.86</td>
</tr>
<tr>
<td><strong>Condensation items</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.95</td>
<td>0.76</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>3.74</td>
<td>0.51</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>3.72</td>
<td>0.76</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.80</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Figure 6.5 Children's responses on the forced-response items about water, evaporation and condensation.

Table 6.10 Analysis of variance for water, evaporation and condensation items on the forced-response section of the interview.

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>27.21</td>
<td>2</td>
<td>13.60</td>
<td>39.12</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>61.55</td>
<td>177</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>88.76</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaporation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>4.82</td>
<td>2</td>
<td>2.41</td>
<td>3.38</td>
<td>.04</td>
</tr>
<tr>
<td>Within groups</td>
<td>126.38</td>
<td>177</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>131.20</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Condensation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1.89</td>
<td>2</td>
<td>0.95</td>
<td>2.00</td>
<td>.14</td>
</tr>
<tr>
<td>Within groups</td>
<td>83.75</td>
<td>177</td>
<td>0.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>85.64</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6.11 *Multiple comparisons for water, evaporation and condensation across primary levels.*

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) Level</th>
<th>(J) Level</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Primary 1</td>
<td>Primary 3</td>
<td>-0.38</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>0.56</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>Primary 3</td>
<td>Primary 1</td>
<td>0.38</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>0.94</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-0.56</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 3</td>
<td>-0.94</td>
<td>0.10</td>
<td>.00</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Primary 1</td>
<td>Primary 3</td>
<td>0.40</td>
<td>0.15</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>0.17</td>
<td>0.15</td>
<td>.53</td>
</tr>
<tr>
<td></td>
<td>Primary 3</td>
<td>Primary 1</td>
<td>-0.40</td>
<td>0.15</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>-0.22</td>
<td>0.15</td>
<td>.35</td>
</tr>
<tr>
<td></td>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-0.17</td>
<td>0.15</td>
<td>.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 3</td>
<td>0.22</td>
<td>0.15</td>
<td>.35</td>
</tr>
<tr>
<td>Condensation</td>
<td>Primary 1</td>
<td>Primary 3</td>
<td>0.20</td>
<td>0.12</td>
<td>.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>.23</td>
<td>0.13</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>Primary 3</td>
<td>Primary 1</td>
<td>-.21</td>
<td>0.13</td>
<td>.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 4</td>
<td>2.222E-02</td>
<td>0.13</td>
<td>.98</td>
</tr>
<tr>
<td></td>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-.2278</td>
<td>0.13</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary 3</td>
<td>-2.2222E-02</td>
<td>0.13</td>
<td>.98</td>
</tr>
</tbody>
</table>

6.2.1.2.2 Children's total scores on all items in the forced-response section of the interview

When the mean of children's total scores on the water, evaporation and condensation items was calculated and plotted, as shown in Figure 6.6, the graph indicated that the mean score for Primary 4 children dropped to levels lower than Primary 3 and Primary 1. A simplified version of the descriptive table on children's performance on each of the items on water and the full ANOVA table (Table 6.12 and Table 6.13) show that significant differences exist among the children on four items. The items were:
• We can live without water,
• There is water in the air,
• Ice is water, and
• Without rain, we will not have water.

![Graph of mean children's total scores](image)

**Figure 6.6** Mean of children's total scores on the forced-response items about evaporation and condensation.

Table 6.14 shows the result on post hoc pair-wise comparison analysis using Scheffe's test. The result indicates that the significant differences between Primary 3 and 4 lie with items:

• We can live without water
• Ice is water
Table 6.12 *Statistics used to test for differences in means between primary levels for every item about water in the forced-response section of the interview.*

<table>
<thead>
<tr>
<th>Items on water</th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>We can live without water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>4.17</td>
<td>1.34</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>4.90</td>
<td>0.54</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>2.72</td>
<td>1.25</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.93</td>
<td>1.43</td>
</tr>
<tr>
<td>Water is everywhere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>4.17</td>
<td>1.34</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>4.25</td>
<td>1.40</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>4.30</td>
<td>1.08</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>4.24</td>
<td>1.27</td>
</tr>
<tr>
<td>There is water in the air</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.82</td>
<td>1.48</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>3.15</td>
<td>1.39</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>2.83</td>
<td>1.37</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.27</td>
<td>1.46</td>
</tr>
<tr>
<td>Ice is water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.95</td>
<td>1.37</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>5.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>3.05</td>
<td>1.29</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>4.00</td>
<td>1.34</td>
</tr>
<tr>
<td>Without rain, we will not have water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1</td>
<td>60</td>
<td>3.18</td>
<td>1.43</td>
</tr>
<tr>
<td>Primary 3</td>
<td>60</td>
<td>3.90</td>
<td>1.47</td>
</tr>
<tr>
<td>Primary 4</td>
<td>60</td>
<td>3.57</td>
<td>1.44</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>3.55</td>
<td>1.47</td>
</tr>
</tbody>
</table>
Table 6.13 The ANOVA results for children's performances on items about water in the forced-response section of the interview.

<table>
<thead>
<tr>
<th>Item</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. We can live without water.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>148.14</td>
<td>2</td>
<td>74.07</td>
<td>60.72</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>215.91</td>
<td>177</td>
<td>1.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>364.06</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Water is everywhere.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>.54</td>
<td>2</td>
<td>.27</td>
<td>0.17</td>
<td>.84</td>
</tr>
<tr>
<td>Within groups</td>
<td>290.18</td>
<td>177</td>
<td>1.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>290.73</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. There is water in the air.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>30.23</td>
<td>2</td>
<td>15.12</td>
<td>7.58</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>352.97</td>
<td>177</td>
<td>1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>383.20</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ice is water.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>114.30</td>
<td>2</td>
<td>57.15</td>
<td>48.24</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>209.70</td>
<td>177</td>
<td>1.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>324.00</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Without rain, we will not have water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>15.43</td>
<td>2</td>
<td>7.72</td>
<td>3.68</td>
<td>.03</td>
</tr>
<tr>
<td>Within groups</td>
<td>371.12</td>
<td>177</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>386.55</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6.14 Multiple comparisons for items about water in the forced-response section of the interview.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) Level</th>
<th>(J) Level</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. We can live without water. Primary 4</td>
<td>Primary 1</td>
<td>-0.073</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 4</td>
<td>1.45</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 1</td>
<td>0.73</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 4</td>
<td>2.13</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-1.45</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 3</td>
<td>-2.18</td>
<td>0.20</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>3. There is water in the air. Primary 1</td>
<td>Primary 3</td>
<td>0.66</td>
<td>0.25</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>0.98</td>
<td>0.25</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 1</td>
<td>-0.66</td>
<td>0.25</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 4</td>
<td>0.31</td>
<td>0.25</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-0.98</td>
<td>0.25</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 3</td>
<td>-0.31</td>
<td>0.25</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>4. Ice is water. Primary 1</td>
<td>Primary 3</td>
<td>-1.05</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>0.90</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 1</td>
<td>1.05</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 4</td>
<td>1.95</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-0.90</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 3</td>
<td>-1.95</td>
<td>0.19</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>5. Without rain, we will not have water. Primary 1</td>
<td>Primary 3</td>
<td>-0.71</td>
<td>0.26</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>-0.38</td>
<td>0.26</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 4</td>
<td>0.71</td>
<td>0.26</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>0.33</td>
<td>0.26</td>
<td>.45</td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 3</td>
<td>-0.33</td>
<td>0.26</td>
<td>.45</td>
<td></td>
</tr>
</tbody>
</table>

The mean score for Primary 3 pupils on the item 'We can live without water' was 4.90. It dropped dramatically to 2.72 for Primary 4 children. The mean score for Primary 4 children on the item 'Ice is water' dropped from 5 for Primary 3 children to only 3.05. As explained in Chapter 4, the item 'Ice is water' was expressed in negative form for the upper primary interview protocol. This was to provide a challenging phrase suitable for older children. Thus, instead of 'Ice is water', it was changed to 'Ice is not water' for Primary 4 children. However, for the purpose of data analysis, the result was later recoded so that the scores obtained were consistent with the Primary 1 and Primary 3 children's scores. The results thus seemed to indicate that significant differences between Primary 3 and 4 lie on two negative
sentences, ‘We can live without water’ and ‘Ice is not water’. It is also important to remember that Primary 4 children were asked these questions in English instead of Malay.

### 6.2.2 Conclusions

There are three features of these results that are worthy of comment. The most significant is the fact that Primary 4 children’s mean scores dropped to a level lower than Primary 3 in the semi-structured interview questions with English responses and in the forced-response interview questions. Further analysis of the forced-response interview indicated that the significant differences lie on two items that were negative statements. Clark and Chase (1972) found that expressing statements as negative could affect comprehension. Coupled with the fact that the Primary 4 children were interviewed in English, it seemed to indicate that the level of comprehension in English for Primary 4 children was low. This result thus serves to underscore the point that the children’s development of understanding was inevitably affected by the change of language from Malay to English when they responded to negative expressions.

There was virtually no significant development of understanding for items about evaporation and condensation from Primary 1 to 4 in the forced-response interview questions (Table 6.9, Figure 6.5) or in the semi-structured interview questions (Table 6.8, Figure 6.4) when children’s responses were only accepted in English in Primary 4. While Brunei children are not taught about these concepts directly in school, peer and family interaction and school experience were considered to be contexts that could provide children with better rationales for explaining the phenomena. This finding indicated that even though ‘possible explanations’ are thought to be developed through interaction with peers and family, the development of understanding was inconsistent with the expected trend. As the concepts are not explicitly taught in the Brunei school curriculum, Primary 3 children’s achievement presented another indication that there is a causal relationship between the unexpected development of understanding and Primary 4 children’s total scores. This finding thus provides the evidence that, as far as Brunei primary school
children are concerned, everyday contexts alone can not assure the development of understanding from Primary 1 to 4 of the concepts of evaporation and condensation.

Finally, the mean score for Primary 3 children on evaporation in the forced-response interview was found to be lower than Primary 1. The difference was in fact significant. This result indicated that, even though the children were all interviewed in Malay and all the interview questions were identical, the age-related development of understanding was not realized for Primary 3 children. The Primary 3 children's result was unexpected and very different from previous studies. The high number of Primary 3 children who provided scientific misconceptions such as 'rain comes from the clouds or sky because frogs call it or the clouds are crying' and 'blue clouds give water to white clouds' in the semi-structured interview questions seemed to correlate with poor performance of Primary 3 in this forced-response interview (Table 6.4). There are a number of factors that may have influenced this unexpected trend in the children's development. First, these phenomena may have been caused by a sampling variation due to individual differences or the nature of the children being tested. Even though the children were randomly selected, the inconsistencies may be due to children with different levels of academic achievement being present in the two groups of children (Primary 1 and 3). Secondly, factors related to the administration of the interviews may have contributed to these phenomena. The interviews were conducted at different times of the day. It is possible that the Primary 3 children were interviewed at a time when they were not constructive and active. Moreover, the children were sent to the resource room for the interview. It might also be possible that they were interviewed when they had interesting things to do in the classroom and were distracted from, or resentful and negative about the interview process.
6.3 Research Question 1c:

Do boys' and girls' conceptions of evaporation and condensation progress in the same way?

This research question was answered by analyzing by gender the mean scores of children's responses to the semi-structured and forced-response sections of the interview.

6.3.1 Findings

Analysis of the research data by gender on the semi-structured and forced-response questions on the concepts of evaporation and condensation yielded the results shown in Table 6.15, Table 6.16, Figure 6.7, Figure 6.8 and Figure 6.9. ANOVA showed that significant differences occurred between the mean scores of boys and girls in all three categories; \( F(5,174) = 5.95, p < .005 \), \( F(5,174) = 12.53, p < .005 \) and \( F(5,174) = 4.40, p < .005 \) for open ended items with only English responses, open ended items with Malay and English responses and forced-response interviews respectively. Scheffe's test, however, pinpointed the following locations for these differences:

A. For children's mean scores in the semi-structured interviews when only English responses were accepted, the differences lie between:
   - Primary 1 males and Primary 3 males
   - Primary 3 males and Primary 4 males

B. For children's mean scores in the semi-structured interviews when English and Malay responses were accepted, the differences lie between:
   - Primary 1 males and Primary 4 males
   - Primary 1 males and Primary 4 females
   - Primary 1 females and Primary 4 males
   - Primary 1 females and Primary 4 females
   - Primary 3 males and Primary 4 males
   - Primary 3 males and Primary 4 females
- Primary 3 females and Primary 4 males
- Primary 3 females and Primary 4 females

C. For children's mean scores in the forced-response interview items, the
differences lie between:
- Primary 1 females and Primary 4 females
- Primary 3 males and Primary 4 females

Table 6.15 Descriptive statistical data for children's responses on the concepts of
evaporation and condensation.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children's mean scores on open-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ended interviews when only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English responses were accepted.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (males)</td>
<td>33</td>
<td>7.33</td>
<td>2.57</td>
</tr>
<tr>
<td>Primary 1 (females)</td>
<td>27</td>
<td>8.59</td>
<td>2.84</td>
</tr>
<tr>
<td>Primary 3 (males)</td>
<td>42</td>
<td>10.33</td>
<td>2.98</td>
</tr>
<tr>
<td>Primary 3 (females)</td>
<td>18</td>
<td>8.11</td>
<td>.96</td>
</tr>
<tr>
<td>Primary 4 (males)</td>
<td>35</td>
<td>8.17</td>
<td>2.52</td>
</tr>
<tr>
<td>Primary 4 (females)</td>
<td>25</td>
<td>7.96</td>
<td>2.47</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>8.55</td>
<td>2.76</td>
</tr>
<tr>
<td>Children's mean scores on open-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ended interviews when Malay and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English responses were accepted.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (males)</td>
<td>33</td>
<td>7.33</td>
<td>2.57</td>
</tr>
<tr>
<td>Primary 1 (females)</td>
<td>27</td>
<td>8.59</td>
<td>2.84</td>
</tr>
<tr>
<td>Primary 3 (males)</td>
<td>42</td>
<td>10.33</td>
<td>2.98</td>
</tr>
<tr>
<td>Primary 3 (females)</td>
<td>18</td>
<td>8.11</td>
<td>.96</td>
</tr>
<tr>
<td>Primary 4 (males)</td>
<td>35</td>
<td>16.74</td>
<td>13.38</td>
</tr>
<tr>
<td>Primary 4 (females)</td>
<td>25</td>
<td>19.92</td>
<td>12.22</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>11.87</td>
<td>8.92</td>
</tr>
<tr>
<td>Children's mean scores on forced-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>response items.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (males)</td>
<td>33</td>
<td>49.90</td>
<td>10.39</td>
</tr>
<tr>
<td>Primary 1 (females)</td>
<td>27</td>
<td>51.96</td>
<td>6.62</td>
</tr>
<tr>
<td>Primary 3 (males)</td>
<td>42</td>
<td>51.54</td>
<td>3.06</td>
</tr>
<tr>
<td>Primary 3 (females)</td>
<td>18</td>
<td>48.77</td>
<td>4.62</td>
</tr>
<tr>
<td>Primary 4 (males)</td>
<td>35</td>
<td>47.34</td>
<td>6.32</td>
</tr>
<tr>
<td>Primary 4 (females)</td>
<td>25</td>
<td>44.84</td>
<td>8.21</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>49.28</td>
<td>7.23</td>
</tr>
</tbody>
</table>
Table 6.16 ANOVA results for boys' and girls' performance on evaporation and condensation.

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children's mean scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on open-ended</td>
<td>Between groups</td>
<td>199.65</td>
<td>5</td>
<td>39.93</td>
<td>5.95</td>
</tr>
<tr>
<td>interviews when only</td>
<td>Within groups</td>
<td>1166.89</td>
<td>174</td>
<td>6.71</td>
<td></td>
</tr>
<tr>
<td>English responses were</td>
<td>Total</td>
<td>1366.55</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>accepted.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Children's mean scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on open-ended</td>
<td>Between groups</td>
<td>3773.82</td>
<td>5</td>
<td>754.76</td>
<td>12.53</td>
</tr>
<tr>
<td>interviews when Malay</td>
<td>Within groups</td>
<td>10479.49</td>
<td>174</td>
<td>60.23</td>
<td></td>
</tr>
<tr>
<td>and English responses</td>
<td>Total</td>
<td>14253.31</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>were accepted.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Children's mean scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on forced-response items.</td>
<td>Between groups</td>
<td>1052.09</td>
<td>5</td>
<td>210.42</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>8320.45</td>
<td>174</td>
<td>47.82</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9372.55</td>
<td>179</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6.7 Boys’ and girls’ responses on semi-structured interviews when only English responses were accepted in Primary 4.

Figure 6.8 Boys’ and girls’ responses on semi-structured interviews when Malay and English responses were accepted.
Figure 6.9 Boys' and girls' responses on forced-response interviews.

When boys' and girls' responses in all three data (Figure 6.7, Figure 6.8, Figure 6.9) were combined and analysed (Figure 6.10), the graphs indicate that the Primary 3 girls did very poorly on these concepts of evaporation and condensation. One factor that might contribute to this finding was the fact that more males than females were interviewed in Primary 3. The number of males was 42 compared with only 18 females. For Primary 1 and 4, the difference between the number of male and female participants were not very significant (Table 4.5, Chapter 4, p. 79).
Figure 6.10 Boys’ and girls’ responses on semi-structured and forced-response interview questions.

6.3.2 Conclusions

Previous research presented the impression that gender was one of the factors that influences success in learning a second language (Clark & Trafford, 1996; Oxford & Ehrman, 1992; Powell & Batters, 1985; Shaaban & Ghaith, 2000; Wright, 1999). It follows that if one gender is better than the other in learning a second language, then it should be assumed that one gender will be better able to explain phenomena in that language. Post hoc tests (Scheffe’s), however, indicated that the means of boys’ and girls’ performances in this study in both semi-structured and forced-response interview questions at the same level did not differ significantly. This suggests that boys and girls in this study performed at a similar level in the interviews about evaporation and condensation.

6.4 General Conclusions and Discussions

The analysis of the results for research question 1a, 1b and 1c suggest that while a general correlation between increase in age and more sophisticated views of the
evaporation and condensation phenomena were observed (research question 1a), the pathway is complex and the boundaries of the conceptual development seemed to be unclear. The patterns in the data also show that there was virtually no significant development of understanding of the cluster of concepts of evaporation and condensation from Primary 1 to 4 for Brunei children. The results in this chapter also indicate that the patterns of children’s understanding of evaporation and condensation are different when the language of interview was changed from Malay to English. The data presented in Figure 6.1 and Figure 6.3 show that Brunei children demonstrated a consistent shift from naïve towards more sophisticated conceptions of the concepts when they provided explanations in their home or mother tongue language, Malay. But, when the Primary 4 children were asked to respond in English, their expressed understandings of the concepts of evaporation and condensation did not progress as expected (Figure 6.2 and Figure 6.4). From these results, it seems that there is more than a correlation, that there is a causal relationship between unexpected negative development of conceptual understanding for Primary 4 children and language transfer from Malay to English. The mean of the scores awarded to Primary 4 children was significantly affected when they provided explanations in English.

There is evidence in this study that individual children’s ways of explaining and expressing their ideas were affected when they tried to explain in English. Because the majority of pupils were incompetent in English, they were inarticulate and hesitant during interviews. The data suggested that the ability or inability of the children to explain was very closely associated with the child’s ability to choose appropriate English words (Tytler, 2000).

As it was apparent that the use of English as a second language hindered the children’s way of explaining and expressing ideas in science, it could be anticipated that gender would also have an impact on ability to express understanding. This hypothesis is supported by previous research that shows gender differences in second language acquisition (Cokley & Wright, 1995; Felder et al., 1994; Togrol & Onur, 2000; Whitelaw, Milosevic & Daniels, 2000). The data from this research, however, showed that boys and girls from Primary 1 to 4 had similar patterns of
development concerning their understanding of the cluster of concepts associated with evaporation and condensation.

The next chapter examines the children's understanding of evaporation and condensation concepts from a conceptual change perspective. The analysis highlights ontological and epistemological conceptual differences that exist in the understandings expressed by children of different primary levels.
CHAPTER SEVEN

CHILDREN’S UNDERSTANDING OF EVAPORATION AND
CONDENSATION:
AN ANALYSIS FROM ONTOLOGICAL AND
EPISTEMOLOGICAL PERSPECTIVES OF CONCEPTUAL
CHANGE

7.0 Introduction

The previous chapter examined and analysed children’s understanding of evaporation and condensation from a developmental perspective. The objective of this chapter is to examine children’s understanding of evaporation and condensation from ontological and epistemological perspectives of conceptual change. Research questions 1d and 1e were formulated to guide this part of the investigation and each of these questions is addressed sequentially in this chapter. In order to answer the research questions, interviews were carried out in 2 phases. In phase 1, Primary 1 and 3 children were interviewed in Malay and Primary 4 children were interviewed in English. In phase 2, more detailed interviews were conducted 14 months later and upper primary children were interviewed in both Malay and English.

In the first phase of interviews, the same four scenarios about evaporation and condensation described in Chapter 6 were used but analysed in a different manner. In the second phase of interviews, the children were asked to respond to one of two questions: (1) What would happen to the wet clothes a few hours after they are hung under a hot sun? and (2) What would happen to the road a few hours after rain? Each child was interviewed individually and in both languages in turn.
7.1 Research Question 1d:

What are the ontological differences about the concepts of evaporation and condensation across the primary levels 1 – 4?

To answer this question, the children’s verbal responses on the four evaporation and condensation scenarios were analysed by reducing the data into different ontologically based categories. Children’s responses were categorised using coding developed by Russell and Watt (1990) and Russell, Harlen and Watt (1989) as described earlier in Chapter 4, section 4.8.3. Children’s responses were categorised into nine categories: uncodeable, perceptual (descriptive), displacement, water cycle image, evaporation, evaporation and water cycle image, water goes into air or atmosphere, water changes to perceptible form and water changes to imperceptible form. These categories were later divided into Chi’s (1992) three basic ontological categories; matter, events and abstractions. The breakdown of children’s responses according to Chi’s Conceptual Change Model is shown in Figure 7.1.

![Diagram](figure7.1.png)

*Figure 7.1* The breakdown of children’s verbal responses.
7.1.1 Findings

The data are presented in a series of six tables (Table 7.1 - 7.6) and two figures (Figure 7.2 - 7.3). The first four tables (Table 7.1, 7.2, 7.3 & 7.4) show the data from each of the four scenarios broken down into the nine response categories and Chi’s three ontological categories. The following two tables provide the combined data from all four scenarios by explanation type (Table 7.5) and ontological category (Table 7.6). While the data presented in this chapter was the same as that previously presented in Chapter 6, the answers were coded and analysed in different ways as explained in the method chapter. In Chapter 6, the data were analysed from a developmental perspective using Bar’s (1989) and Bar and Galili’s (1994) explanation categories (Tables 6.1, 6.2, 6.3 & 6.4) and in this chapter, data were analysed from an ontological perspective using Chi’s (1992) categories (Tables 7.1, 7.2, 7.3 & 7.4). Moreover, children’s responses in Malay were coded as ‘ uncleadeable’ in this chapter.

From Tables 7.1 - 7.6 and Figures 7.2 - 7.3, it is evident that the majority of children’s explanations about evaporation and condensation fall in the categories; perceptual, displacement and water cycle image. The most frequent response type was the perceptual (descriptive) with 55.3% of all children providing this kind of explanation, however, there were a number of children who gave uncodeable explanations.

7.1.1.1 Uncodeable explanations

A significant number of Primary 1 children (37.5%) either did not make any attempt to respond to the questions about the four scenarios or the responses did not make sense and could not be matched with any of the categories. More Primary 3 children attempted to give explanations than the Primary 1 children with only 10% giving no response (Table 7.6). Significantly, there was an increase in the number of Primary 4 children (33.3%, Table 7.6) who gave an ‘uncodeable’ response compared with Primary 3. In fact, the percentage of Primary 4 children (33.3%) who gave an ‘uncodeable’ response was almost the same as Primary 1 (37.5%). For Primary 4 children, Malay verbal responses were classified as ‘uncodeable’ because, first, they were interviewed in English and second, it was the aim of this study to examine the
children's conceptual understanding when the language of instruction is changed from Malay to English in Primary 4. The reason why a large portion of Primary 4 children gave uncodeable responses is clearly associated with the change in the language of the interview.

7.1.1.2 Matter ontological explanations of evaporation and condensation

Table 7.6 shows that there were some children from each of the primary levels who were able to give an explanation that could be categorised as matter, an event or an abstraction according to Chi's (1992) ontological categories. The number of children who could give each of these explanations varied, however, and in the following paragraphs the variations in the proportions of children will be considered. The most common kind of response provided by the Primary 1, 3 and 4 children overall, fell under the category of matter (52.1% of the responses) (Table 7.6). Within this category, 43% of Primary 1 children gave a perceptual or descriptive kind of explanation, for example, "the water dries up". The other 9.1% were more precise with their explanation, for example, "the water drips to the ground". These children's responses were described as 'displacement' because they could explain that the water was not just disappearing but was actually dripping to the ground. For Primary 3, 72.5% of the children gave a perceptual (descriptive) type of response. This represents an increase of 29.5% from Primary 1. Interestingly, the number of Primary 3 children who provided displacement explanations decreased compared with Primary 1 from 6.2% to 9.1%. This could be because more children had attempted to respond with a perceptual type of explanation. There was also a decrease in the number of Primary 4 children who provided the perceptual or descriptive as well as the displacement kinds of explanations compared with Primary 3. Altogether, only 52.1% of Primary 4 children, compared with 78.8% of Primary 3, provided an explanation under the category of matter. In fact, the percentage was the same as the Primary 1 children.
Table 7.1 The distributions of children’s verbal responses on the puddles of water scenario.

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n = 60)</th>
<th>Primary 3 (n = 60)</th>
<th>Primary 4 (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncodeable</td>
<td>33 (55%)</td>
<td>21 (35%)</td>
<td>32 (53.3%)</td>
</tr>
<tr>
<td><strong>MATTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual (descriptive)</td>
<td>4 (6.6%)</td>
<td>23 (38.3%)</td>
<td>24 (40%)</td>
</tr>
<tr>
<td>Displacement</td>
<td>22 (36.6%)</td>
<td>15 (25%)</td>
<td>4 (6.6%)</td>
</tr>
<tr>
<td><strong>EVENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cycle image</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>ABstractions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaporates and water cycle image</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 7.2 The distributions of children’s verbal responses on the wet clothes scenario.

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n = 60)</th>
<th>Primary 3 (n = 60)</th>
<th>Primary 4 (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncodeable</td>
<td>21 (35%)</td>
<td>2 (3.3%)</td>
<td>18 (30%)</td>
</tr>
<tr>
<td><strong>MATTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual (descriptive)</td>
<td>39 (65%)</td>
<td>57 (95%)</td>
<td>41 (68.3%)</td>
</tr>
<tr>
<td>Displacement</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>EVENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cycle image</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>ABSTRACTIONS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaporates &amp; water cycle image</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 7.3 The distributions of children’s verbal responses on the water in a dish scenario.

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n = 60)</th>
<th>Primary 3 (n = 60)</th>
<th>Primary 4 (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncodeable</td>
<td>24 (40%)</td>
<td>1 (1.6%)</td>
<td>17 (28.3%)</td>
</tr>
<tr>
<td><strong>MATTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual (descriptive)</td>
<td>32 (53.3%)</td>
<td>59 (98.3%)</td>
<td>43 (71.6%)</td>
</tr>
<tr>
<td>Displacement</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>EVENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cycle image</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>ABSTRACTIONS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaporates &amp; water cycle image</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 7.4 The distributions of children’s verbal responses on the picture of the water cycle.

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n = 60)</th>
<th>Primary 3 (n = 60)</th>
<th>Primary 4 (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncodeable</td>
<td>12 (20%)</td>
<td>0</td>
<td>13 (21.6%)</td>
</tr>
<tr>
<td><strong>MATTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual (descriptive)</td>
<td>28 (46.6%)</td>
<td>35 (58.3%)</td>
<td>13 (12.6%)</td>
</tr>
<tr>
<td>Displacement</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>EVENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cycle image</td>
<td>20 (33.3%)</td>
<td>13 (12.6%)</td>
<td>28 (46.6%)</td>
</tr>
<tr>
<td><strong>ABSTRACTIONS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Evaporates &amp; water cycle image</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 7.5 *The distributions of children’s verbal responses based on the categories on the four evaporation and condensation scenarios.*

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n=60)</th>
<th></th>
<th></th>
<th>WC</th>
<th></th>
<th>Primary 3 (n=60)</th>
<th></th>
<th></th>
<th>WC</th>
<th></th>
<th>Primary 4 (n=60)</th>
<th></th>
<th></th>
<th>WC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
<td>P</td>
<td>C</td>
<td>D</td>
<td></td>
<td>WC</td>
<td></td>
<td>P</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Uncodeable</td>
<td>33</td>
<td>21</td>
<td>24</td>
<td>12</td>
<td></td>
<td>21</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td>32</td>
<td>18</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Perceptual (descriptive)</td>
<td>4</td>
<td>39</td>
<td>32</td>
<td>28</td>
<td></td>
<td>23</td>
<td>57</td>
<td>59</td>
<td>35</td>
<td></td>
<td></td>
<td>24</td>
<td>41</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>Displacement</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water cycle image</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Evaporates and water cycle image</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td></td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td></td>
<td></td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

P – What would happen to a puddle of water, one hour after rain? Why?
C – What is happening to wet clothes as they are hung under the sun? Why?
D – Water in a dish left under the sun disappears. Why?
WC – Describe the picture of a water cycle.
Table 7.6 Total number of children presenting the respective types of responses on the four scenarios combined.

<table>
<thead>
<tr>
<th>Explanation type</th>
<th>Primary 1 (n = 240)</th>
<th>Primary 3 (n = 240)</th>
<th>Primary 4 (n = 240)</th>
<th>Total (n = 720)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncodeable</td>
<td>90 (37.5%)</td>
<td>24 (10%)</td>
<td>80 (33.3%)</td>
<td>194 (26.9%)</td>
</tr>
<tr>
<td>Perceptual (Descriptive)</td>
<td>103 (43%)</td>
<td>174 (72.5%)</td>
<td>121 (50.4%)</td>
<td>398 (55.3%)</td>
</tr>
<tr>
<td>Displacement</td>
<td>22 (9.1%)</td>
<td>15 (6.2%)</td>
<td>4 (1.6%)</td>
<td>41</td>
</tr>
<tr>
<td><strong>MATTER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total = 125</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Cycle Image</td>
<td>21 (8.8%)</td>
<td>13 (5.4%)</td>
<td>29 (12.1%)</td>
<td>63 (8.8%)</td>
</tr>
<tr>
<td><strong>EVENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporates</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Evaporates &amp; Water cycle Image</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Water goes into air or atmosphere</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>ABSTRACTIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes to perceptible form</td>
<td>0</td>
<td>13 (5.41%)</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Changes to imperceptible form</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total = 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.7%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total = 14</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5.8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total = 6 (2.5%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3.3%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Explanation types

Figure 7.2 Bar chart presenting the number of children who gave each type of response.

Chi’s ontological categories

Figure 7.3 Bar chart presenting the number of children in each of Chi’s categories.
Even though both perceptual and displacement responses are categorised in the same ‘matter’ category, the perceptual responses focus upon the perceptual elements only. Displacement responses also focus on the perceptual elements, however, these responses provide an explanation of what has been observed, for example, that “water in the clothes is disappearing [because] the water is dripping to the ground”. Nevertheless, the difference between the number of Primary 3 and Primary 1 children providing the displacement explanation is not as significant as the difference between the number of Primary 3 and Primary 4 children. Thus, as far as the ontological category of matter is concerned, there was an increase in the number of children who gave a matter kind of response from Primary 1 to Primary 3. The number of Primary 4 children giving this kind of response, however, decreased considerably compared with Primary 3 (Table 7.6).

7.1.1.3 Event ontological explanations of evaporation and condensation

Only 8.8% of Primary 1 children managed to provide an explanation that fell into the category of event. The water cycle image, or the type of responses which required the children to mention something that indicated that they understood that water is evaporated, seemed to be intangible for these young children. Fewer Primary 3 (5.4%, Table 7.6) than Primary 1 children (8.8%, Table 7.6) gave an explanation that could be described as an event. The reason for the low proportion of Primary 3 children giving an event explanation could be because there was a bigger percentage of Primary 3 children who gave abstract explanations. Compared with Primary 3, there was a two-fold increase, from 13 to 29, in the number of Primary 4 children who provided an explanation that fell in the ontological category of event. This initially seems to indicate an improvement from Primary 3 to Primary 4 in the number of children who were able to explain using an event ontological explanation. However, it is important to note that there was a reduction in the number of Primary 4 children who gave an abstract explanation. It could be that the Primary 4 children who gave an abstract explanation in Malay could only give an event explanation in English.
7.1.1.4 Abstract ontological explanations of evaporation and condensation

All four Primary 4 children who gave an abstract type of response referred to water going into the air. Even though they could not see this happening, these children seemed to be able to sense that “water goes into the air”. A total of 5.8% Primary 3 children, an increase of 4.1% from Primary 1, managed to give responses that were in the category of abstraction. One child provided the third type of explanation, that is, water goes into the air or atmosphere and thirteen gave responses classified as changes to perceptible form. Overall, this data supports the suggestion that Primary 3 children can provide more sophisticated ontological explanations than Primary 1 children of the concepts. At the same time, there also was a decrease in the percentage of Primary 4 children, compared with Primary 3, who gave abstract ontological explanations. In fact, the explanations that the Primary 4 children provided under the category of abstraction were only categorised as the first three examples in the list of the abstract explanations. These responses refer to the use of the word evaporation only; a combination of evaporation and water cycle image, and water goes into the air or atmosphere respectively. As mentioned earlier, 13 Primary 3 children were able to provide the fourth explanation under the category of abstraction. It can, therefore, be tentatively suggested that on-the-whole Primary 3 children were able to provide more sophisticated ontological explanations in Malay than the Primary 4 children could provide in English.

7.1.2 Conclusions

The answer to the research question: “What are the ontological differences about the concepts of evaporation and condensation across the primary levels 1 – 4?” can be answered by examining the summary of the categorizations of the children’s ontological responses (Table 7.6). The results from Table 7.6 show that the children from each of the three primary levels could provide responses for all three ontological categories; matter, event and abstractions. There are variations, however, in the percentages of children from each level who provided responses for each category. For example, in the event category, the number of Primary 1, 3 and 4 children who gave this kind of explanation about the four scenarios were 21, 13 and 29 respectively (Table 7.6).
A small number of Primary 1 children, aged between 6 and 7 years managed to provide responses under the category of abstraction. This observation supports Bar and Galili’s (1994) finding that while the explanation that “water is absorbed in the floor and/or ground” is common for children between seven and eight years of age, some children in this age group also could have the view that “water is transferred into an alternative location, for example, to the air”. The minor difference is that in this study, the children are one year younger than the children investigated by Bar and Galili. Alternatively, Tytler (2000) and Tytler and Peterson (2000b) found that each child in their study, of whatever age, all substantially drew upon the earlier ‘stages’. This study, thus, supports Tytler’s and Tytler and Peterson’s findings.

While the children were not explicitly taught the topic of evaporation and condensation in school, the data in Table 7.6 show that Primary 3 children seemed to provide more ontologically sophisticated explanations than the Primary 4 children. Moreover, more Primary 4 children gave more ‘uncodeable’ responses compared with Primary 3 children. These results are inconsistent with expected trends. According to Tytler (2000), Year 6 Australian students have a greater precision in distinguishing between fundamental ontological categories such as matter, events and abstract entities. Therefore, the expected pathway for the development of children’s ontological understanding should reflect a correlation between the level of sophistication of explanations and increasing primary levels.

It can therefore be concluded from these data that the expected development of children’s ontological explanations of evaporation and condensation was not realised for children in Primary 4. This is the transition period when the language of instruction in school is changed from Malay to English. This seems to suggest that the children’s conceptual development was influenced by the change in language of instruction.
7.2 Research Question 1e:

What is the status of the children’s conceptions of evaporation and condensation from Primary 1 – 4?

This research question was answered by utilising an epistemological perspective of conceptual change and analysing the status of the children’s conceptions about evaporation and condensation from the second phase of interviews. The conceptual change model developed by Posner et al. (1982) and researched extensively by Hewson and Hewson (1992) and Hewson and Thorley (1989) was used to identify the status of the children’s conceptions. This model measures whether the concept is intelligible, plausible and fruitful to the learner. The method for interpreting the status of children’s conceptions about evaporation and condensation based on their responses during interviews was explained in detail in Chapter 4 section 4.8.4. The status of the children’s conceptions about evaporation and condensation both when they responded in Malay and English is summarized in Table 7.7. The overall patterns in the data that are evident in Table 7.7 are outlined in the discussion below. Subsequently, a series of cases are presented that illuminate the qualitative aspects of the status of the children’s conceptions. In particular, cases where the status changed are the focus of this qualitative data.

7.2.1 Findings

When questioned in Malay, the status of all of the 18 children’s conceptions of evaporation and condensation were intelligible (Table 7.7). Eight of these children also had conceptions that were plausible and two children spontaneously produced intelligible, plausible and fruitful explanations (Table 7.7). Surprisingly, none of the Primary 6 children interviewed had a fruitful conception. When the children were interviewed in English, all children, except one, gave intelligible conceptions, four had intelligible and plausible conceptions and only one had an intelligible, plausible and fruitful conception (Table 7.7). All Primary 6 children provided intelligible conceptions in English except one who had an imprecise status. In English, it was a Primary 6 child who provided a fruitful conception.
When interviewed in English, there were four cases where the status was different from the status in their Malay interview (Case #12, 16, 17 and 18). These students are highlighted in Table 7.7. Case #16 had a higher status explanation when asked to respond in English (fruitful rather than plausible). Case #12 and #18, in contrast, gave explanations with a lower status. For Case #17, the status of the conception in Malay was intelligible and plausible but not fruitful. The status of the child’s conception in English was, however, imprecise because it varied at different points during the interview. At one point, it seemed that the status was intelligible and plausible and hence there was no change in status of the conception from Malay to English. At another point of the interview, the status of the child’s conception seemed to be intelligible but not plausible.

For the purpose of presenting the qualitative evidence of the status of the conceptions of the 18 children interviewed and for corroborating the claim that the status of conceptions in the Malay interview changed when interviewed later in English, relevant interview excerpts are included in the following section. All interviews conducted in Malay are translated into English.

7.2.1.1 Status of conceptions when interviews were in Malay

7.2.1.1.1 Intelligible but not plausible and fruitful

Case 1: Laila (Aged 8)

During the first phase of interviews, Laila was asked “why would the wet clothes become dry after a few hours?” Her response that “the water dripped to the ground” was categorized as a displacement type which is within the ontological category of matter. In the second phase of interviews, she was asked to elaborate her ideas. The status of her displacement conception was found to be intelligible but not plausible and fruitful. Laila explained that the water will go to the drain. However, her displacement conception was not plausible because she said “I don’t know [where the water would go from the drain]”. Laila also could not transfer her displacement conception to the alternative context of water in a dish left in a room. She responded, “I think so” when asked if she believes that water left in a dish would eventually decrease. An excerpt from the second phase of interviews with Laila follows.
Table 7.7 The status of children’s conceptions of evaporation and condensation.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Primary level in 2001</th>
<th>Primary level in 2003</th>
<th>Chi’s ontological category</th>
<th>Status of conceptions when interviewed in Malay (A)</th>
<th>Status of conceptions when interviewed in English (B)</th>
<th>Any changes in status from A to B?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>Matter</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>3</td>
<td>Matter</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>3</td>
<td>Processes</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3</td>
<td>Processes</td>
<td>Intelligible, plausible and fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>3</td>
<td>Abstraction</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>3</td>
<td>Abstraction</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>5</td>
<td>Matter</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Intelligible but not plausible and fruitful</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>5</td>
<td>Matter</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible and plausible but not fruitful</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>5</td>
<td>Processes</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible and plausible but not fruitful</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>5</td>
<td>Processes</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Intelligible but not plausible and fruitful</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>5</td>
<td>Abstraction</td>
<td>Intelligible, plausible and fruitful</td>
<td>Intelligible, plausible and fruitful</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>5</td>
<td>Abstraction</td>
<td>Intelligible, plausible but not fruitful</td>
<td>Not intelligible, not plausible and not fruitful</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>6</td>
<td>Matter</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible and plausible but not fruitful</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>6</td>
<td>Matter</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible and plausible but not fruitful</td>
<td>No</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>6</td>
<td>Processes</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Intelligible but not plausible and fruitful</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>6</td>
<td>Processes</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible, plausible and fruitful</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>4</td>
<td>6</td>
<td>Abstraction</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Imprecise status</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>6</td>
<td>Abstraction</td>
<td>Intelligible and plausible but not fruitful</td>
<td>Intelligible but not plausible and fruitful</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Laila’s Malay interview (translated into English):

Interviewer: Why do you think the water dripped to the ground?
Laila: It was hot. There was a sun.
Interviewer: What do you think will happen to the water in a dish which is left in a room? Would it disappear after some time?
Laila: No, because it is not hot. Only if water is left in the sun will it disappear.
Interviewer: Where would the water go?
Laila: It would go to the drain.
Interviewer: Ok. Where would the water go from the drain?
Laila: Hm... I don't know.
Interviewer: Will it [the water] go into the air?
Laila: No.
Interviewer: If I said that water in a dish left in a room will eventually decrease, would you believe me?
Laila: Hm...well...I think so.
Interviewer: Do you have any idea where would the water go?
Laila: I don't know.

7.2.1.1.2 Intelligible and plausible but not fruitful

Example 1

Case 2: Rina (Aged 9)

In the first phase of interviews, Rina provided explanations that fell under the category of matter. She gave a displacement explanation ("water flows to the drain") for the scenario of a puddle of water and perceptual or descriptive explanations for scenarios of wet clothes, water in a dish and the water cycle ("it is hot", "there is a sun" and "there is rain" respectively). In the second phase of interviews, Rina gave an abstract explanation ("water goes up to the air") that was found to be intelligible and plausible but not fruitful. When asked why the road would become dry, Rina initially replied that the sun "sucked the water'. But when prompted within a different context, Rina had the confidence to say that water goes up into the air. This
explanation indicated that her abstract conception was intelligible to her. Not only was her conception intelligible, it also was plausible because Rina had a quick answer “yes” to the statement that there is water in the air that showed her confidence and belief in this conception.

The following excerpt from the interview demonstrates that the status of her conception was not fruitful. This was because she did not initially believe that water in a dish in a room will disappear after some time. However, when Rina was probed further, she replied that the water will decrease because of the fan in the room. This indicates that, for Rina, there has to be an external mechanism, such as the fan, to enable the water to go into the air. Rina’s abstract conceptions were, therefore, intelligible and plausible but not fruitful.

Rina’s Malay interview (translated into English):

Interviewer: Why do you think the road will become dry?
Rina: The sun ‘sucked’ the water.
Interviewer: Are you saying that the water will go up to the sun?
Rina: No.
Interviewer: If you drink water using a straw, then you’re sucking up the liquid.
Rina: Er…. Yes, the water goes up.
Interviewer: Where?
Rina: I think it goes to the air.
Interviewer: So, there is water in the air.
Rina: Yes.
Interviewer: What do you think will happen to the water in a dish which is left in a room? Would it disappear after some time?
Rina: No. There is no sun. The water is not hot!
Interviewer: If I said that water in a dish left in a room will eventually decrease, would you believe me?
Rina: Hm… yes.
Interviewer: Why?
Rina: (Thinking) I think because there is a fan in the room.
Interviewer: What does the fan do to the water?
Rina: It dries up the water.
Interviewer: How?
Rina: I don’t know. But the water goes down.
Interviewer: But you said, water on the road will eventually go up to the air.
Rina: Hm.... Yes (hesitated). It goes up to the air.

Example 2

Case 8: Ali (Aged 11)

During the first phase of interviews, Ali provided an overall conception that fell under the category of matter. When asked “why would the [wet] clothes become dry after a few hours?”, he responded, “the sun is hot”. He also provided perceptual explanations to the scenario of water in a dish and the picture of a water cycle. On the puddle of water scenario, he gave a displacement explanation that “water flows to the drain”.

In the second phase of interviews, he was asked to elaborate where the water went. The status of the perceptual and displacement conceptions was found to be intelligible for Ali because he understood that water goes into the air. His conception was also plausible because he believed that the water disappeared “just like that”. Even though it was not really a scientific explanation, Ali had a quick answer to the question that indicated that he was confident that his conception was true. His conception was, however, not fruitful because he was not able to transfer his science concept to the water in a bowl which is left in a room.

Ali’s English interview:

Ali: It [the water] goes to the drain.
Interviewer: Does the water also go into the air?
Ali: Yes.
Interviewer: How does it go up?
Ali: Just like that!
Interviewer: What about water kept in a bowl in this room?
Ali: The water will not go up! Water will disappear if there is a sun. Hm.... The air here [in the room] does not contain water because there is no sun in here. Also at night...there will be no water in the air during nighttime. Roads will also remain wet.

Example 3

Case 6: Fitri (Aged 9)

In the first phase of interviews, Fitri's responses to the four evaporation and condensation scenarios fell under the category of abstraction. When asked “what happened to the water in a dish?” and to describe a picture of a water cycle, Fitri responded that “the water goes up into the air”. This explanation can be categorized as an abstract explanation. There also was evidence of an abstract explanation in the second interview as Fitri once again responded that “water goes into the air”.

Through the second phase of interviews, the status of Fitri's conception was found to be intelligible and plausible because not only did he understand that water goes into the air, he was convinced and believed that water ‘must’ go into the air to make rain. The connection between water going into the air and rain made the concept plausible to Fitri. Fitri expressed the plausibility through his use of the word ‘must’. This indicates he really believed that water does go into the air, so that it can rain. His conception was not fruitful, however, because he could not transfer his science conception to the new context of water in a dish. The conception was not useful to Fitri in a different context.

Fitri’s Malay interview (translated into English):

Fitri: Water goes into the air.
Interviewer: How do you know it goes up into the air?
Fitri: [It] must go up to make rain.
Interviewer: What about water in a dish which is left in a room? Will the water level decrease?
Fitri: The water will eventually disappear. But it will take a very long time. Er...It [the water] won't escape to the air.

Interviewer: So, where does the water in the air come from?

Fitri: Only from the seas, rivers, the roads....

Interviewer: What makes you think that?

Fitri: Because..... the water [from the seas, rivers, and the road] is exposed to the sun!

Interviewer: Where do you think the water in the dish left in the room will go?

Fitri: Just disappear....

Interviewer: Where to? How?

Fitri: I don’t know.

Interviewer: Goes into the air?

Fitri: Hm.....(thinking) may be (hesitate). I’m not sure.

7.2.1.1.3 Intelligible, plausible, fruitful

*Case 4: Azri (Aged 9)*

Azri’s conception during the first interview fell under the category of processes, because he mentioned that water goes to the sky. In the second interview, Azri managed to provide a simple explanation of the situation of wet clothes being hung under the hot sun. His conception was assessed as being intelligible, plausible and fruitful because he made connections between water in the air and dew, which indicated his conception was useful to him in a different context and hence was fruitful. For Azri, his response in the second interview was consistent with the first. Even though he could not provide a detailed scientific explanation of the phenomena, he easily associated ‘water goes up to the sky’ with the presence of ‘dew’. Most pupils interviewed believed that water goes up to the sun and if there is no sun, it does not ‘disappear’ or evaporate. There seemed to be a strong connection for most children between the process of evaporation and the sun. Thus, when Azri declared that water in a room would also disappear even if it is not hot, this was a good indication that his conception was fruitful.
Azri's Malay interview (translated into English):

Azri: The sun dries up the water.
Interviewer: Where does the water go?
Azri: The water goes up to the sky.
Interviewer: How do you know?
Azri: Um..... because sometimes there is dew.
Interviewer: Is the dew made of water?
Azri: Yes. You can feel it.
Interviewer: That means the water goes into the air.
Azri: Yes.
Interviewer: Is it because the water is hot?
Azri: Not necessarily. Water in the room also disappears even if it is not hot.

7.2.1.2 Status of conceptions when interviews were in English

7.2.1.2.1 Intelligible but not plausible and fruitful

Case 7: Ahmad (Aged 11)

Ahmad provided an explanation that fell under the category of matter when he was first interviewed in 2001. On the puddle of water scenario, he provided a displacement explanation. On wet clothes, water in a dish and water cycle scenarios, he simply provided perceptual explanations. Fifteen months later, he was approached for the second time and was asked to respond in two languages, Malay and English. In his English interview, he was asked about the scenario of the drying of a wet road, his conceptions were assessed as intelligible but not plausible and fruitful. It was difficult to assess if his displacement conception was intelligible or not because initially he did not know where the water would go. When probed with leading interview questions (to the ground?), he was more confident to say that the water will drip to the ground but not go into the air. However, Ahmad did not indicate that he believed this was true. Even though he had experienced evaporation and could explain that water 'disappears' he could not articulate any explanation for the evaporation phenomenon. Since 'water drips to the ground' is one of the ways of
representing an unsophisticated scientific conception for this scenario, Ahmad's displacement conception was accepted as intelligible but not plausible and fruitful.

Ahmad's English interview:

Interviewer: What would happen to the road a few hours after the rain?
Ahmad: I don't know.
Interviewer: Will the road become dry?
Ahmad: Yes.
Interviewer: Where does the water go?
Ahmad: (Shaking his head) I don't know.
Interviewer: To the ground?
Ahmad: Yes.
Interviewer: Air?
Ahmad: No.
Interviewer: What about water in a bowl which is left in a room? Will the water disappear after sometime?
Ahmad: Hm... I don't know.

7.2.1.2.2 Intelligible and plausible but not fruitful

Case 14: Ajib (Aged 12)

Ajib's initial explanation was purely perceptual which put his idea in the category of matter. When he was interviewed for the second time, the displacement conception was found to be intelligible because he could explain, through broken English, the evaporation phenomenon [the water ....flow...to the...river, the river will .... into the air]. This conception also can be classified as plausible to Ajib because he agreed with the interviewer that he really does believe it goes into the air. When probed further, however, the perceptual conception was not fruitful for Ajib. His explanation that there is no water in the interview room [because...(there are) no clouds!] indicates a misconception that the only water in the air is in the form of visible clouds. This precludes fruitfulness because Ajib's conception was not a useful explanation in another context.
Ajib’s English interview:

Ajib: The water flows ... in the drain and dry.
Interviewer: Will the water also go into the air?
Ajib: Er.... Up in the air ... (hesitate)!
Interviewer: Is there any water in the air?
Ajib: Er... yes (still hesitate).
Interviewer: Do you see the water go into the air?
Ajib: No.
Interviewer: Then, what makes you think that there is water in the air?
Ajib: The water.... flow.... to the... river, the river will .... into the air.
Interviewer: Do you really think that there is water in the air?
Ajib: Yes.
Interviewer: Is there any water in the air in this room?
Ajib: No.
Interviewer: Why?
Ajib: Because...[there are] no clouds!

7.2.1.2.3 Intelligible, plausible and fruitful

Case 11: Mohamad (Aged 11)

Mohamad was probably the most insightful of all the children interviewed. During the first interview, his response fell under the category of abstraction. When asked to describe a picture of a water cycle, he responded that “...rain comes from the clouds. There is water in the clouds. The water comes from the sea. When it is hot, the water changes to vapour and it goes up”.

In the second phase of interviews, he also managed to provide an explanation with the highest status when asked to explain the phenomena in Malay. The excerpts from Mohamad’s Malay interview (and translated into English) and English interview were first mentioned in Chapter 6, p. 153 - 154. In Chapter 6, Mohamad’s conceptions of evaporation and condensation when he explained in both Malay and English were compared. In this chapter, however, Mohamad’s English responses are
analysed epistemologically, in order to ascertain whether the status of his conception is intelligible, plausible or fruitful. Mohamad was confident and articulate and he spontaneously provided an explanation to the situation of the wet clothes when asked in Malay. The status of his conception was described as intelligible, plausible and fruitful because not only did he understand that water goes into the air, he was convinced and believed that water ‘must’ go into the air to make rain, and could transfer his knowledge to the new context of water in a bowl.

When asked to explain the phenomena in English, Mohamad did not seem to be able to explain as confidently as when he was asked in Malay. There had to be leading interview questions before Mohamad could articulate the key explanations to the phenomena. Because of his inability to explain his ideas with fluent English, Mohamad’s spoken words were not convincing. Yet, when his responses were analyzed in a broad sense, the conceptions were considered intelligible, plausible and fruitful (the transcripts has been displayed in previous chapter, refer to Chapter 6, p. 153 - 154).

7.2.1.3 Change of status of conceptions when interviews were initially in Malay and later in English

7.2.1.3.1 Conceptions were plausible when interviewed in Malay but not intelligible when interviewed in English

Case 12: Osman (Aged 10)

During the first interview, Osman gave a response which was ontologically categorized as an abstraction. Osman responded that water changes to vapour and that water vapour goes up into the air. In the second phase of interviews, Osman provided an interesting case where the status of his conception changed with the change of language. When he was interviewed in Malay, the status of Osman’s abstract conception was intelligible and plausible. His response in English was, however, assessed as not intelligible.

In Malay, the status of Osman’s abstract conception was intelligible and plausible because he understood that water goes into the air and said he is sure this happens.
This indicates that his conception was plausible. However, he believed that water in the air becomes ice [or cold?] and then expressed confusion when the interviewer asked if the clouds are ice. Osman seemed to have a good understanding of the phenomena when asked if it (water in the clouds) becomes rain. However, when he responded he tended to say "yes" softly, suggesting that he was not sure. Later in the interview, Osman said the water becomes steam in the air. His conception seemed to be fruitful in some regards, as he said that water which is not exposed to the sun directly will also disappear so he was able to apply the conception to a different context. However, he suddenly associated the disappearing of water with the fan inside the room. This indicates that Osman believed that there needs to be an external mechanism, such as fan, to enable the water to go into the air. Although his abstract conception was intelligible and plausible, it was not fruitful because it did not allow Osman to explain evaporation in a different context:

Osman’s Malay interview (translated to English):

Osman: The water will go into the air. Some will drop to the ground and soak in.
Interviewer: So there is water in the air.
Osman: Yes.
Interviewer: How do you know? Are you sure about this?
Osman: Yes… We’ve learnt this.
Interviewer: What happens to the water in the air?
Osman: After some time the water becomes ice.
Interviewer: Is there any ice there? (pointing to the clouds)
Osman: Yes.
Interviewer: Are you saying that the clouds are made up of ice?
Osman: Oh… No! (Shock)
Interviewer: Then… what happens to the water in the air?
Osman: I don’t know.
Interviewer: Will it become rain later?
Osman: Yes… (softly)
Interviewer: What about water in a bowl left in a room? Will the water decrease?
Osman: Yes... some of the water will go into the air.
Interviewer: Even though the water is not exposed to the sun directly?
Osman: Yes... There is a fan here (pointing to the fan).
Interviewer: So...there is water in the air!
Osman: Yes, there is water in the air.
Interviewer: Can you see the water?
Osman: No...because it becomes steam...and we cannot see steam!

When Osman was interviewed in English, the only word that he managed to utter was "wet". His ability to explain was extremely limited when he was asked to respond in English to the point that the status of his conception was not intelligible, not plausible and not fruitful because he could not articulate any explanation for the evaporation phenomena. This interview is in stark contrast with the previous interview in Malay where Osman was able to discuss and express his ideas that water from wet clothes and water from a dish in a room goes into the air. The previous interview also could be used to diagnose more specific misconceptions, for example, that Osman believed that an external mechanism, such as a fan, is required to enable evaporation. None of these ideas were evident in Osman's interview in English. It can therefore be assumed that his potential to discuss scientific phenomena and engage in scientific discourse at school is severely limited when classes are conducted in English.

Osman's English interview:

Osman: (Silent)
Interviewer: Will the clothes become dry?
Osman: (Silent)
Interviewer: Still wet? Or Dry?
Osman: Wet!
Interviewer: Yes... but what would happen after a few hours?
Osman: (Silent)
Interviewer: Will the clothes become dry?
Osman: (Shaking his head)
7.2.1.3.2 Conceptions were plausible when interviewed in Malay but not plausible when interviewed in English

*Case 18: Darina (Aged 11)*

Darina was another child whose status of conception changed with the change of language. When probed in Malay, the status of her conception was intelligible and plausible but not fruitful. However, when interviewed and asked to respond in English, the status of her conception changed to intelligible but not plausible and fruitful. Her response during the first interview was ontologically categorized as abstraction, the most sophisticated category. When asked to describe the picture of a water cycle, she responded that water from the ocean evaporates. Even though she did not elaborate on this term, her response was categorized as abstract. Despite this, in the second round of interviews 18 months later, Darina failed to provide an abstract explanation in both Malay and in English.

When Darina was interviewed in Malay, the status of her conception was intelligible and plausible because she understood and believed that water must go into the air to make rain. However, Darina seemed to fluctuate between plausible and not plausible at different points of the interview. It may be that for the drying of clothes scenario, the abstract conception was intelligible and plausible to Darina, but in the context of the bowl of water in a room, this abstract conception was only intelligible and not plausible. Her conception seemed plausible when she responded, “...because if there is no water in the air, how can we have rain”. Later, Darina said that she did not believe that there is water in the air in a room. This is an example of a conception that changed status in different contexts. Darina’s conception was, therefore, not fruitful because she could not satisfactorily transfer her science conception to a different context.

Darina’s Malay interview (translated into English):

*Darina:* The road will become dry. The sun is shining and the water [on the road] becomes hot. Water will go into the air, to the drains, rivers....

*Interviewer:* Hm.... Are you saying that there is water in the air?

202
Darina: I think so!
Interviewer: What makes you think that there is water in the air?
Darina: Because.... because..... if there is no water in the air, how can we have rain!
Interviewer: Will water left in a room disappear too?
Darina: No.
Interviewer: If that is the case, then you're saying that there will be no water in the air in this room, right?
Darina: Yes, there is no water in.....(thinking).....eh.... I think there is.
Interviewer: What happens to the water in the air?
Darina: Hm.... is there any water in the air [in this room]?
Interviewer: Yes!
Darina: Hm.... (looking around)....(still thinking).
Interviewer: Don't you believe that?
Darina: I don't believe it.
Interviewer: So, you know that there is water in the air, someone told you, but you don't believe it!
Darina: Yes, I don't believe it.

Almost all of Darina's responses to the interview questions in English were simply answered with "yes". It is very difficult to determine status from such a dialogue because it is not clear whether she actually agrees with the interview when she says "yes", or whether she is simply responding without understanding.

Darina's English interview:

Darina: Apakan? (What is it?)
Interviewer: One hour after the rain, what would happen to the road?
Darina: (No response)
Interviewer: Will the road become dry?
Darina: Yes.
Interviewer: Where would the water go?
Darina: Go... tempat longkang (to the drain)
Interviewer: Will it also go into the air?
Darina: Yes.
Interviewer: What makes you think that there is water in the air?
Darina: (Smiling).... I don't....
Interviewer: Is there any water in the air?
Darina: Yes.
Interviewer: Will drops of water on the floor in this room disappear after a few hours?
Darina: Yes.
Interviewer: Is there any water in the air in this room?
Darina: Yes (but still looking around!)
Interviewer: Are you sure?
Darina: Yes.

7.2.1.3.3 Conceptions plausible when interviewed in Malay but fruitful when interviewed in English

Case 16: Udin (Aged 11)

Analysis of Udin's Malay and English verbal responses indicated that the status of his conception progressed to a higher level from plausible, when he was communicating in Malay, to fruitful when he was communicating in English. An excerpt from Udin's Malay interview (translated into English) has already been presented in Chapter 6, p. 148. In this chapter, the same data is used to show the different status when he responded in English.

This is an exceptional case where the conception raised in status when the response was given in English. His initial response to this phenomenon when he was interviewed for the first time was ontologically categorized as an event. When asked about the scenarios of a puddle of water, wet clothes, water in a dish and the picture of a water cycle, Udin responded that water goes to the sun. He also mentioned that rain comes from the clouds but did not elaborate further.

In the second phase of interviews, Udin was asked “what would happen to the [wet] clothes a few hours after they are hung under the hot sun?” Udin's response in
Malay indicated that the status of his conception was intelligible and plausible because he could articulate a scientific explanation to the evaporation phenomena and he also believed this scientific explanation to be true, because it explained for him that “water vapour falls down as rain”. The scientific conception connected well with his existing knowledge about rain. His conception was, however, not fruitful because he could not transfer his knowledge to a new context of water in a bowl. There is one indication that his conception was fruitful because at one point in the interview he agreed with the statement that water in a dark room will escape into the air. But he did not seem very convinced. When he was asked the same question earlier, he gave a quick answer “no” indicating that he was confident that water in a room does not go into the air. He changed his mind in the interview because of the interviewer’s probing questions.

The status of Udin’s conception, when interviewed in English was intelligible, plausible and fruitful. Not only did he understand that water goes into the air and was convinced that the ‘evaporated’ water will make rain, he also was able to make connections with new situations of water in a bowl and the process of evaporation at night.

Udin’s English interview:

Udin: After a few hours, the clothes that I put outside, that has germs, the germs will gone.

(At this point, it was not clear if he was referring to bacteria or fungi that are killed by the sun’s radiation. It might be possible that he was influenced by the science topic he was learning at the time of interview).

Interviewer: Will the clothes become dry after a few hours?
Udin: The clothes will dry.
Interviewer: Where would the water go?
Udin: Water go …. in the air.
Interviewer: Where else will it go?
Udin: er…. (pointing to the ground)
Interviewer: Ground?
Udin: Yes.
Interviewer: Is there any water in the air?
Udin: No. Hm... yes...yes... there is water in the air.
Interviewer: Can you see it?
Udin: Yes, when it is raining...Hm... the water will become water vapour.
Interviewer: What makes you think that?
Udin: Geography.
Interviewer: Oh...you've learnt this in a geography lesson?
Udin: Yes. Water falls as rains...when the clouds is heavy.
Interviewer: That's interesting. But will water in a bowl left in this room also disappear after some time?
Udin: Yes.
Interviewer: But last time, you said the water will not disappear!
Udin: It was wrong before.
Interviewer: Where would the water go?
Udin: Water go into the air. If there is open window, water go into the air outside. This is evaporation. Water go to the clouds and becomes rains.
Interviewer: Will evaporation occur at night?
Udin: Yes.

7.2.1.4 Conceptions were intelligible but not plausible and fruitful even though earlier conceptions fell under the category of abstraction

Example 1

Case 17: Wan (Aged 12) Imprecise Status of Abstract Conception

When he was interviewed for the first time, Wan provided an explanation that fell under the category of abstraction, the most sophisticated quality of response. When asked to describe a picture of a water cycle, he responded that “rain comes from the clouds. The clouds have water. The rain comes from the ocean. Water in the ocean evaporates”.
The status of his conception for his second interview was intelligible. However, it was quite difficult to precisely determine whether or not his conception was plausible. His conception was intelligible because he responded that “the water is going up into the air”. Wan’s conception seemed to fluctuate between plausible and not plausible at different points in the interview, especially when the interviewer changed the context of the evaporation. This may have been due to the use of the English language. When asked whether there is water in the air, Wan initially replied “maybe” and “I don’t know”. These were good indications that his abstract conception (water is going up into the air) was not plausible. Also in this second Malay interview, Wan used the word ‘evaporation’ (in English) to help him explain the evaporation phenomena. He did not spontaneously use the word ‘evaporation’ in his English interview, however, the interviewer chose to ask if he had ever heard of evaporation. When prompted with the English word ‘evaporation’ he had the confidence to articulate his abstract conception of a water cycle in broken English. He was convinced that water ‘must’ go into the air to become water vapour and to make rain. The connection between water going up in the air and vapour gas and rain once again indicated the abstract conception was plausible to Wan.

The status of his abstract, water cycle conception was not fruitful because he could not make connections between evaporation and water at night. Not only was his abstract conception not fruitful, his response to the question, “will all water evaporate?” showed that he had misconceptions. Wan thought that not all water evaporates and that ‘only sea and outside’ water will. Moreover, according to Wan, evaporation does not occur at night. When asked why the road is sometimes dry in the morning when it was raining during the night, Wan responded that it would become dry because of evaporation. He understood this scientific conception, however, it was not plausible. He could say what happened, but he was not convinced because he said “maybe”.

Wan’s English interview:

Wan: After a few hours, the clothes will dry because the water is going up into the air.

Interviewer: Do you see it?

Wan: No.
Interviewer: So, is there any water in the air?
Wan: Yes...er...maybe.
Interviewer: What makes you think that there is water in the air?
Wan: I don't know.
Interviewer: Have you heard of the process of evaporation?
Wan: Yes.... Yeah... evaporation [is] about water going up and .... it goes up it becomes vapour gas... and it....at the end it becomes the water... and it goes down as rain.
Interviewer: Will all water evaporate?
Wan: No.
Interviewer: What kind of water will evaporate then?
Wan: Only sea and outside.
Interviewer: Does evaporation occur at night?
Wan: No.
Interviewer: But.. if it rains in the evening and the rain stops, why would the road be dry in the morning?
Wan: Because..... of evaporation.
Interviewer: So, evaporation does occur at night, or when there is no sun!
Wan: Hm... Maybe!

Example 2

Case 5: Elena (Aged 9)

Elena's conception was assessed as intelligible, but not plausible and fruitful in the second interview. In the first interview, Elena provided an explanation that fell under the category of abstraction, the strongest quality of response. She explained that water goes up into the air on the scenario of water in a dish. The idea that water can go into the air shows that her conception was intelligible. Even though she seemed to know that water goes into the air in the second phase of interviews, there was no evidence that she really understood this concept because she could not give a reason or further explanation for her idea. When probed, she admitted that she was “just guessing”. This was a good indication that her conception was not plausible.
Elena’s Malay interview (translated to English):

Elena: When the rain stops, the sun starts to shine. The water becomes hot and it just dries up.
Interviewer: What really happens when it [the water] becomes hot?
Elena: Hm... (shaking her head) I don’t know.
Interviewer: Do you know where the water goes?
Elena: Er... I think to the air.
Interviewer: What makes you think that?
Elena: I don’t know. I’m just guessing.
Interviewer: What happens to the water when it goes into the air? Can you see the water?
Elena: It just disappears.
Interviewer: All of the water just disappears into the air?
Elena: Hm... (still thinking)... Some goes into the earth.

7.2.2 Conclusions

There are three features of these findings that are worthy of comment. The first assertion is that there is no correlation between the primary level of the children and the status of their explanations. At one level, interviews in Malay seemed to indicate that the older children constructed explanations with a higher status than the younger children. For example, only one child in Primary 6, two in Primary 5 and three in Primary 3 did not have a plausible conception. This indicates that the higher the primary level, the more children had plausible conceptions. Closer inspection, however, reveals that this was not the case. The two children who had constructed conceptions with the highest status of fruitfulness were from Primary 5 and Primary 3. Similarly, when interviewed in English, Primary 5 and 6 children were shown to have conceptions of a relatively similar status.

The second assertion is that increasing sophistication of explanations based on Chi’s (1992) ontological categories is inconsistent with the development of status according to Hewson and Hewson’s (1992) conceptual change model. The ability to provide more sophisticated ontological explanations according to Chi, did not necessarily mean that the conception had a higher status for the children. Likewise,
the children's conceptions which had the highest status, as evident from the interview, were not necessarily associated with higher degrees of abstraction in Chi's ontological model. All the explanations which were ontologically categorized as an abstraction during the first interview, were found to be intelligible but not necessarily plausible or fruitful for the children.

The third and final assertion is that for some children, verbal responses illustrated differences in status when they provided explanations in the two different languages. There were four cases presented in this chapter that demonstrated, to some extent, that a change in language changed the status of the child's conception. Three cases, Osman (Case #12), Wan (Case #17) and Darina (Case #18) provided explanations with a lower status in English. Another case, Udin (case #16) had a conception with a higher status in English. There is evidence in the transcript from Osman's interview that the status of his conception was intelligible and plausible, but not fruitful, when he tried to explain in Malay. The status was no longer intelligible, however, when he was asked to respond in English. Close inspection of the interview reveals that, for Osman, English language had a substantial effect on his ability to explain. When asked in English, the only word that Osman uttered was "wet" and most of the time he just kept silent. The change of the tone of the interview, from friendly and expressive to cold and reticent communication, supports the idea that he had limited access to and confidence with English words. As a result, and at face value, he was shown to have 'difficulty' in understanding scientific concepts. Darina's conception was intelligible and plausible but not fruitful when she first responded in Malay. When asked to explain in English, her conception was intelligible, but no longer plausible. Again, when Darina's interview transcript was analysed, it was noticed that she found it difficult to understand the English questions. She tried, at least, to reply to most of the questions. However, in most cases, she could not convey clear responses.

Like Darina, Wan's conception was also intelligible and plausible but not fruitful when he responded in Malay. When he responded in English, however, the status of his conception was imprecise. There is evidence in the transcript that the status of his conception fluctuated between plausible and not plausible. For Wan, the use of English language probably caused him to express his ideas differently. Thus, for
Osman, Darina and Wan, English language was the main cause for their inability to provide explanations of high status. Interestingly, Udin (case #16) had a conception with higher status when he responded in English. In Malay, his conception was intelligible and plausible but not fruitful. In English, the status of his conception was intelligible, plausible and fruitful. One thing worth mentioning is that Udin used the words 'water vapour' (in English) to help him explain the phenomena in Malay. Obviously, he 'borrowed' the English words to make his explanations clearer. This finding broadly supports the dimensions of learning science in languages other than English identified by Buck, Dent and Umpleby (2000). Buck et al. report that English language is the key to explaining scientific concepts more clearly. Udin had learnt this idea in a geography lesson. As he had attended to this phenomenon, he must have understood the incident using the appropriate English words. With greater accessibility in choosing words (Tytler, 2000), Udin was shown to be able to provide an explanation with a higher status.

These results present an interesting contradiction that highlights the conundrum of the choice of language for Brunei science education. On one hand, English can, at times, enable higher status explanations to be generated, but on the other hand, the disruption of the English language when used for classroom communication can impede conceptual understanding.

7.3 General Conclusions and Discussions

In general, it seems that the language transition from Malay to English adversely affected developmental indications of conceptual change in several ways. First, according to Chi’s (1992) model, the ontological categories of the conceptions used by children were negatively influenced by the transfer of language as the children progressed from Primary 3 to Primary 4. Moreover, there was evidence that the use of the English language inhibited the children’s expression and hence the status of their conceptions according to Hewson and Hewson’s (1992) conceptual change model. It also was observed in this study that an increase in status did not necessarily correlate with more sophisticated ontological conceptions and vice versa.
The results also demonstrated the value of using more than one perspective of conceptual change to interpret children's understanding of science. Different perspectives of conceptual change have been shown to illustrate different aspects of children's conceptions and expressions of understanding in science. The use of more than one perspective thus allows a researcher to obtain an holistic picture of conceptual change (Harrison & Treagust, 2001; Venville & Treagust, 1998).
CHAPTER EIGHT

CHILDREN'S UNDERSTANDING OF LIVING AND NON-LIVING THINGS:
AN ANALYSIS FROM DEVELOPMENTAL AND ONTOLOGICAL PERSPECTIVES

8.0 Introduction

Children's understanding of evaporation and condensation has been critically examined and discussed in the previous two chapters. In this chapter, the extent to which individual children develop understanding of the cluster of science concepts related to living and non-living things is examined. This chapter will examine children's understanding of living and non-living things from both a developmental perspective and an ontological perspective of conceptual change. This chapter first explores children's naïve conceptions and the general patterns of understanding that develop with age, through the language transition in Primary 4. Subsequently, the data are scrutinized through an ontological lens (Carey, 1985; Chi, 1992) to determine the ontological conceptual differences that exist in the understandings expressed by children of different primary levels.

Four research questions - 2a, 2b, 2c and 2d - were designed to guide this part of the investigation and each of these questions is addressed sequentially in this chapter. Fifteen children were randomly chosen from each of the five primary levels of 1, 3, 4, 5 and 6 (n = 75) to participate in this part of the study. The children were interviewed using both the semi-structured interview items and forced-response interview items. For the purpose of this chapter, the categorization task which was part of the semi-structured interview was analysed separately. Thus there are three sets of data a) semi-structured interview, b) the categorization task and c) the forced-response interview.
8.1 Research Question 2a:

What are Brunei children’s naïve conceptions about living and non-living things?

An attempt was made to account for Brunei children’s naïve conceptions and the possible origins for these conceptions of living and non-living things. In order to probe their ideas, the children were guided by the semi-structured interview questions about living and non-living concepts. The results from the categorization task are included in the data that are presented to answer this research question. However, a more detailed analysis of the categorization task is discussed and presented separately to answer the next research question.

8.1.1 Findings

Because the concepts of living and non-living things are taught formally in schools in Brunei, it was anticipated that children acquire basic words in English that are associated with these concepts. Therefore, for the upper primary children, only English responses to all questions were accepted.

8.1.1.1 Things that are living

The first question in the semi-structured interview required the children to name some things that are living. The children gave a variety of responses (Table 8.1) but it is clear that the majority of children (36 of 75) only gave an example of an animal as something that is living. Other children said that animals and people (11), animals and plants (8) and people (7) are examples of living things (Table 8.1). When the children were asked this question, they preferred to mention the word ‘binatang’ (animals) rather than name individual animals, for example, ‘a cat’ or ‘a cow’. The Primary 3 children’s responses were quite different when compared with the other primary levels because none said that animals alone are living things (Table 8.1). Nine of the 15 Primary 3 children said that animals, people and plants are all examples of living things and 6 of the remaining children said animals and people are examples of living things. This was quite extraordinary compared with the
Primary 6 children, 12 of whom said animals are living things. It may be that the Primary 3 children had been taught that plants and people are living things.

Table 8.1 *Things children gave as examples of living things in the semi-structured interview questions.*

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Animals</th>
<th>Animals and plants</th>
<th>Animals and people</th>
<th>People</th>
<th>Car, fan etc (non-living things)</th>
<th>Animals, people and plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 15)</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Primary 3 (n = 15)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4 (n = 15)</td>
<td>0</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Primary 5 (n = 15)</td>
<td>0</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Primary 6 (n = 15)</td>
<td>0</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total (n = 75)</td>
<td>1</td>
<td>36</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

8.1.1.2 *Death and living things*

When the children were further probed in the semi-structured interviews with the question, “Was a dead cat ever living?”; it was found that the majority of Primary 1 children denied previous life to dead objects because 80% responded “never” (Table 8.2). Not only did the Primary 1 children frequently have this idea, 86.6% of the Primary 3 children, aged between 8 and 9 years also thought that a dead cat was never living (Table 8.2). The percentages of older children, aged 9 and above with the same conception were 20%, 6.6% and 13.3% for the Primary 4, 5 and 6 children respectively. With regard to the notion of life before death, one Primary 6 pupil strongly disagreed with the statement in the forced-response interview questions that, ‘all things in this world fall into two main categories of living and non-living’. When asked why he strongly disagreed, he said that there is another group besides ‘living’ and ‘non-living’, that is “dead people”. It is very difficult for adults to
conceive why children might think that dead things have never been alive. For a potential explanation, we can turn to the work of Slaughter et al. (1999).

Table 8.2 Responses to the question, "Was a dead cat ever living?" in the semi-structured interview questions.

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Yes, once living</th>
<th>No, never living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 15)</td>
<td>1</td>
<td>2</td>
<td>12 (80%)</td>
</tr>
<tr>
<td>Primary 3 (n = 15)</td>
<td>0</td>
<td>2</td>
<td>13 (86.6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Yes, once living</th>
<th>No, never living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 4 (n = 15)</td>
<td>1</td>
<td>11</td>
<td>3 (20%)</td>
</tr>
<tr>
<td>Primary 5 (n = 15)</td>
<td>4</td>
<td>10</td>
<td>1 (6.6%)</td>
</tr>
<tr>
<td>Primary 6 (n = 15)</td>
<td>0</td>
<td>13</td>
<td>2 (13.3%)</td>
</tr>
<tr>
<td>Total (n = 75)</td>
<td>6</td>
<td>38</td>
<td>31</td>
</tr>
</tbody>
</table>

Slaughter et al. (1999) proposed that children's concept of 'death' develops at the same time as their conception of 'living'. The data from this study shows that the majority of Primary 3 children, aged 9, lacked the biological concept of 'death' because they did not understand that a dead cat once lived. There seemed to be a clear shift in thinking between Primary 3 and Primary 4 when many more children understood that a dead cat once lived. When comparing Brunei children with the children in Slaughter et al.'s study, there seems to be a three-year delay in this shift in understanding. According to Jaakkola (as cited in Slaughter et al., 1999), a major shift could be observed between the ages of 6 to 10 when children became 'life-theorizers' that is, they developed the ability to give specific functional explanations of how organisms maintain life. Only when children are life-theorizers are they able to demonstrate concurrent development in a cluster of related concepts and beliefs including the concepts of 'life', 'death' and 'body function' (Slaughter et al., 1999). The Brunei children's understanding of death that developed between the ages of 9 and 10 may be better explained by Jaakkola's notion of 'life-theorizers'.

216
8.1.1.3 Children's understanding of the word 'living'.

The fourth question in the semi-structured interview probed the children's understanding of the word 'living' simply by asking them to explain their understanding. Some children gave no response to this question, other children misinterpreted the question. However, the vast majority of children said 'yes' when asked, 'Do you know what living means?' and elaborated their understanding of living by spontaneously giving examples of living things and reasons why they considered these things to be living. The responses were analysed by documenting the spontaneous criteria the children used when describing their understanding of the word 'living' and are presented in Table 8.3.

When asked what living means, 14.6% of the children interviewed did not respond to the interviewer (Table 8.3). These children may not have had any idea what living means, or alternatively, they chose not to communicate their ideas. Even if they had an idea in their mind, it could have been that they were afraid to discuss their idea because they were not confident of the accuracy. It is likely that the majority of Brunei children have never heard a precise definition of 'living' and they may prefer not to give an answer at all than to give an answer that is not correct. The number of children who gave no response did not vary significantly across the primary levels (Table 8.3).

The process of interviewing the children with semi-structured interview items did present some interesting differences between the children interviewed in Malay and those interviewed in English with regard to their understanding of the word 'living'. There were relatively few problems presenting the questions to lower primary children because they were asked in Malay, their home or mother tongue language. However, for a few upper primary children, who were interviewed in English, the researcher had to translate the word 'living' into Malay because their responses obviously reflected a misunderstanding of the word. These children tended to consider the English word 'living' as grammatically similar to the word 'live' as in "where do you live?" The following interview excerpt demonstrates this confusion:

"Do you know what living means?"
"Yes."
"What does it mean?"
"Kampung Sumbiling." (name of a place where the pupil lived).

Table 8.3 The scientific criteria that children used when asked to describe what living means in the semi-structured interview questions.

<table>
<thead>
<tr>
<th>Criteria used</th>
<th>Primary 1 n = 15</th>
<th>Primary 3 n = 15</th>
<th>Primary 4 n = 15</th>
<th>Primary 5 n = 15</th>
<th>Primary 6 n = 15</th>
<th>Total n = 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>11 (14.6%)</td>
</tr>
<tr>
<td>Movement</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>21 (28%)</td>
</tr>
<tr>
<td>Movement and growth</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Movement and breathing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Movement/ growth/ nutrition</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Movement/ growth/ nutrition/ breathing</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Movement and nutrition</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Movement/ nutrition/ breathing</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>9 (12%)</td>
</tr>
<tr>
<td>Movement/ hunt for food/ hide from predators</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Movement/ have hearts, livers and lungs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Movement/ growth/ nutrition/ breathing/ reproduction</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Movement/ nutrition/ breathing/ reproduction</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

This demonstrates that English language proficiency for a few upper primary children was very limited firstly, because they responded in Malay rather than
English and secondly, because they misunderstood the English word ‘living’. However, the word ‘living’ is indeed used in English to indicate the place where we live. For example, “I’m living in the city”. Therefore, such a mistake by these students is not unreasonable, particularly considering their English as a second language status.

Such poor language proficiency could have influenced the children’s interview responses in two respects: first, it might have restricted their ability to express their ideas, and second, their expressed conceptions may not have reflected their true understanding of the concept living but rather of another, more limited, concept. The criteria used by the children and their patterns of understanding are further described in the following section.

8.1.1.4 Patterns in children’s understandings of the concept of living

Table 8.3 shows the criteria that the children used when they were asked to describe what living means in the semi-structured interview questions. Children from Primary 1, 3, 4, 5 and 6 who responded to the question, “What does it [living] mean?” used characteristics such as running, jumping and flying, as their main way of describing their understanding of the concept ‘living’ (85.4%, Table 8.3). For example;

“Kalau ia hidup, ia dapat berjalan dan terbang.”
(If it is alive, it can move and fly)
“Berjalan, berlari, melompat...”
(Walking, running, jumping...)

It is notable that the children’s conceptions of living involved descriptions that were often restricted to the scientific criterion of movement with 28% of all children describing their concept of living in this way (Table 8.3). However, some children used movement as their first point of reference for explaining their understanding of this concept but also used other descriptors such as growth and the need for nutrition (Table 8.3). Examples of such explanations follow:

“Benda hidup boleh berjalan, membesar dan makan.”
(Living things ‘walk’, grow and take in food)

"Kalau benda itu hidup, ia boleh bergerak, membesar, bernafas dan beranak."

(Living things move, grow, take in food, breathe and reproduce)

After the use of the movement criteria alone, the next most frequently used combination of criteria was movement and nutrition with 17 (22.7%, Table 8.3) children explaining that living things move and require nutrition in some way. Nine children (12%, Table 8.3) described their understanding of living using the criteria of movement, nutrition and breathing.

Table 8.3 shows a general trend from Primary 2 to Primary 6 of children spontaneously using more than one criterion to describe their understanding of living. For example, 8 of the 15 Primary 1 children used the movement criterion alone. Conversely, the number of Primary 6 children who used the movement criterion alone was only 1, with the majority of Primary 6 children spontaneously describing their understanding of living using additional descriptors such as nutrition and breathing (Table 8.3). Following are examples of the scientific criteria used by the children to demonstrate how they responded to this question.

A. The following set of responses demonstrates examples of children using characteristics of organisms that represent the scientific criterion of movement:

(P indicates the child’s primary level)

"Ia boleh berjalan dan terbang." (It walks and flies) (child #6, P1)

"Ia pandai bertiari." (A person runs) (child #4, P3)

"It jumps and runs." (child #3, P4)

"It swims." (child #6, P6)

B. The following set of responses demonstrates examples of children using characteristics of organisms that represent the scientific criterion of nutrition:

"Ia boleh makan dan minum." (It eats and drinks) (child #1, P1)

"It eats." (child #7, P5)

"It hunts for food." (child #8, P6)
C. The following response demonstrates an example of a child using characteristics of organisms that represent the scientific criterion of respiration:

"It has a heart, it breathes." (child #3, P5)

D. The following response demonstrates an example of a child using characteristics of organisms that represent the scientific criterion of reproduction:

"It gives birth (to?)." (child #15, P6)

E. The following response demonstrates an example of a child using characteristics of organisms that represent the scientific criterion of response or irritability:

"It hides from predators." (child #8, P6)

A pattern that emerges from the data suggests that in these semi-structured interview questions there was a broader use of scientific criteria by the older children that reflects a more sophisticated understanding of living things. Even though the word 'living' had to be translated into Malay for some of the upper primary children, Table 8.3 does not show a strong deviation from this general trend as the language changes from Malay to English between Primary 3 and Primary 4. While this reflects a substantial level of conceptual development by the older children, their understandings are likely to be restricted to animals only. This is evident from previous data that 65 children (or about 90.3% of all children who responded correctly to the question, "Can you tell me some things that are living?") cited 'animal' as their major example of a living thing (Table 8.1). Whether Brunei children consider plants as living things is further explored in the next section.

8.1.1.5 How children differentiate between animals and plants

Data for this section was gathered from two questions in the semi-structured interviews, first, children's responses to the question, "Do you think a plant is living or not living?" from the categorization task (Table 8.4), and second, children's explanations of their decisions to group a set of pictures of animals and plants. For this activity, the children were asked, "Do you think these (animals and plants) are
living or not-living?’ (Table 8.5) and ‘In what ways are these (animals and plants) different?’ (Table 8.6).

The findings again broadly support the patterns identified by Carey (1985). The analysis of children’s responses about whether plants are living or not in two different contexts provided an interesting finding. The results shown in Table 8.4 and Table 8.5 indicate that age, which is represented by primary level, clearly correlates with the relative understanding of the children. Older children tended to have a concept of plants as living things compared with the younger children who said plants are not living. When asked (in the categorization task) if a plant is living or not living, only 2 (13.3%, Table 8.4) of the Primary 1 children said that it is living. The rest, or the majority, considered plants not living on the basis of movement and nutrition. This group of young children aged between six and seven years did not utilize criteria of living other than ‘movement’ and ‘nutrition’. For children in Primary 3 onwards, or when they are eight years old and above, many start to consider plants alive. Similarly, when asked “Do you think these (plants and animals) are living or not-living?” in the semi-structured interview, 14 (93.3%, Table 8.5) Primary 1 children said that plants are non-living whereas animals are living.

Table 8.4 Children’s responses to the question, “Do you think a plant is living or not living?” in the categorization task.

<table>
<thead>
<tr>
<th></th>
<th>Living</th>
<th>Non-living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 15)</td>
<td>2 (13.3%)</td>
<td>13</td>
</tr>
<tr>
<td>Primary 3 (n = 15)</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td><strong>Change of medium of instruction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4 (n = 15)</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Primary 5 (n = 15)</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Primary 6 (n = 15)</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total (n = 75)</strong></td>
<td><strong>47</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>
Table 8.5 Children’s responses to the question, “Do you think these (plants and animals) are living or not-living?” in the semi-structured interview.

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Plants and animals are all living</th>
<th>Plants non-living: animals living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 15)</td>
<td>1</td>
<td>0</td>
<td>14 (93.3%)</td>
</tr>
<tr>
<td>Primary 3 (n = 15)</td>
<td>0</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

Change of medium of instruction

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Plants and animals are all living</th>
<th>Plants non-living: animals living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 4 (n = 15)</td>
<td>2</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Primary 5 (n = 15)</td>
<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Primary 6 (n = 15)</td>
<td>0</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Total (n = 75)</td>
<td>4 (5.4%)</td>
<td>48 (64%)</td>
<td>23 (30.6%)</td>
</tr>
</tbody>
</table>

Table 8.6 Children’s responses to the question, “In what ways are these (plants and animals) different?” in the semi-structured interview.

<table>
<thead>
<tr>
<th></th>
<th>Primary 1 (n = 15)</th>
<th>Primary 3 (n = 15)</th>
<th>Primary 4 (n = 15)</th>
<th>Primary 5 (n = 15)</th>
<th>Primary 6 (n = 15)</th>
<th>Total (n = 75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>19 (25.3%)</td>
</tr>
<tr>
<td>Plants do not move, take in food,</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>28 (66.7%)</td>
</tr>
<tr>
<td>breathe and reproduce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants have roots, animals have</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5 (6.6%)</td>
</tr>
<tr>
<td>eyes, nose etc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants do not have hearts</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Plants are non-living things</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>22 (29.3%)</td>
</tr>
</tbody>
</table>
Table 8.4 and Table 8.5 also demonstrate a very clear change according to Piagetian descriptions of development (Bybee & Sund, 1982). At the Primary 1 level, the majority of children are, according to Piaget, still in the preoperational period where they are very much influenced by perceptual evidence. Only by about age seven, or when they are in the concrete operational stage, do they start to develop reasoning strategies. Concepts of animals and plants hence can coalesce into the broader superordinate category of living things (Carey, 1985).

When the children were further probed through the question, “In what ways are these (plants and animals) different?”, approximately 39% (Table 8.6) of the participants across the primary levels distinguished animals from plants on the basis of movement and body functions, a finding which is roughly consistent with Tema’s concept of ‘animal-centredness’ (1989). They also seemed not to appreciate the similarity of other biological processes that occur in both plants and animals. In Carey’s (1985) study, children at the age of 10 understood that animals and plants share biological properties such as breathing and growing. However, in this study, Primary 5 children, aged between 10 and 11 years, considered that animals have different biological properties compared with plants. In fact, 10 (66.7%, Table 8.6) Primary 6 children, or the majority aged between 11 and 12 years, tended to differentiate plants from animals on the basis that plants do not move, take in food, breathe and reproduce. From the outset, the older children in this study seemed to be able to judge plants as living things. Further analysis, however, shows that the children still considered plants to possess different biological properties compared with animals. These findings are demonstrated in the following quotations from transcripts.

Movement

Almost all the children used movement as a criterion to distinguish plants from animals.

For example:

“Plants do not move, just like a table.” (child #12, P3)
“Animals move, feed.... Uummm, plants don’t.” (child #5, P4)
“A plant is living...but it cannot move and eat. Animals can.” (child #1, P5)

**Body functions**

The children mentioned breathing and reproduction as characteristics of animals. However, they did not consider them as processes in both plants and animals. The majority felt that plants do not breathe and reproduce. Feeding also was a criterion used to distinguished plants from animals. Interestingly, they thought that vegetables are ‘not’ plants because they can be eaten and that plants do not need food.

For example:

“Plants are non-living because they do not breathe, they don’t have hearts, they don’t walk.” (child #3, P5)

“They (animals and plants) both grow. But animals breathe and move, plants don’t.” (child #6, P6)

“Animals breathe but plants don’t.” (child #1, P6)

“Animals reproduce and have a skeleton, plants don’t.” (child #14, P5)

“Plants are living...but vegetables are not! We eat them!” (child #15, P5)

“Animals need food. They eat meat and plants. Plants do not need food. They only ‘make’ food.” (child #4, P6)

It seems that ‘having hearts’ (Table 8.6) is a criterion of living used not only by children in this study but also in the United Kingdom (Venville, 2004). Child #4, from Primary 6, gave an interesting explanation that plants ‘only make food’. This particular child had correctly classified plants as living and grouped the pictures of animals into mammals, amphibians, reptiles, birds and fish, showing that he or she had developed a sophisticated concept of biological classification. However, this child had a very ‘animal-centred’ perception of ‘living’ that plants ‘make food’ presumably for animals.

Five children overall (6.6%) distinguished animals from plants based on physical features such as ‘plants have roots’, ‘animals have eyes, noses, etc.’ (Table 8.6). While 22 (29.3%) of the children categorized animals as living and plants as non-living, 19 children (25.3%) gave no reason for the difference. It is interesting to note
that when asked, "Do you think these (plants and animals) are living or not-living?" (Table 8.5), only 4 of the children from all primary levels did not respond to the question. The number of non-responders, interestingly, increased to 19 when the children were asked, "In what ways are these (plants and animals) different?" A possible reason why the number of non-responders increased could be that the question, "In what ways are these (plants and animals) different?" was more demanding than the question, "Do you think these (plants and animals) are living or not-living?" The first question was open-ended and required the children to provide more words in their explanation. For upper primary children, if their English language proficiency was limited, the way they answered this question would certainly have been affected.

One item in the forced-response interview explored children’s conceptions about a person being an animal. The next section develops this idea in detail.

8.1.1.6 How children classify people

Though the child’s concept of a person has not been the main focus of this study, the data retrieved in one of the forced response items leaves no doubt that this concept plays a central role in Brunei primary school children’s understanding of the concept living. When asked if a human being is an animal, 80% of Primary 1 children strongly disagreed and 60% of Primary 3 children either strongly disagreed or disagreed with the statement (Table 8.7). About half (53.3%) of Primary 4 children thought that a human being is an animal. While 40% of Primary 5 children either strongly disagreed or disagreed with the statement, 46.6% said they were unsure. Even in the oldest Primary 6 group, 73.3% of the children did not consider a human being an animal (Table 8.7).

The relationship between children’s concepts of animal and human being are complex. The difficulties could be related to children failing to attribute the characteristics of animals to people. Beyond that, the participants in this study could be influenced and confused by the difference between the common or everyday meaning and scientific meaning of the word ‘animal’ (Bell & Freyberg, 1985). For example, the presence of the sign ‘No animals allowed’ in many shops in Brunei
could be a factor inhibiting the children’s understanding that, from a scientific point of view, human beings are animals.

Table 8.7 Children’s responses to the forced-response item, ‘A human is an animal’.

<table>
<thead>
<tr>
<th></th>
<th>I don’t know</th>
<th>strongly disagree</th>
<th>disagree</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1 (n = 15)</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Primary 3 (n = 15)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4 (n = 15)</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Primary 5 (n = 15)</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Primary 6 (n = 15)</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total (n = 75)</td>
<td>14</td>
<td>31</td>
<td>13</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

8.1.2 Conclusions

The Brunei children in this study, similar to other children throughout the world, were found to have naïve, non-scientific conceptions about the concepts of living and non-living things. The majority of these children seemed to have a narrow understanding of ‘living things’ as something similar to scientists’ understanding of the concept ‘animal’. This is likely to be a consequence of these children’s preference for the use of the criteria ‘movement’ and ‘nutrition’ to identify living things and may be related to their first language views (see Table 8.3). For primary school aged children, these criteria are likely to limit their understanding of living things to animals because movement and feeding are only clearly perceivable in animals. Older children did show a tendency to use a broader spectrum of scientific criteria for living things, such as reproduction and breathing, but did not apply these criteria to plants. This indicates a number of misconceptions, particularly about plants.

Brunei children in this study also did not have a good understanding of the concept of death, with a three year delay in being able to correctly answer the question, ‘was a dead cat ever living’ compared with other children (Slaughter et al., 1999).
Finally, the use of the English language from Primary 4 onwards appeared to introduce further potential for Brunei children to misunderstand the concepts living and non-living. Many children associated the English word ‘living’ with a dwelling or place of residence, completely misinterpreting the scientific discussion of the interview with the everyday way in which the word is used in English.

8.2 Research Question 2b:

Is there any indication of a pattern of development of understanding of the concept of living and non-living things from Primary 1 – 6? What impact does language transition have on this pattern of development?

This research question was investigated by analysing quantitatively the children’s responses on a) the semi-structured interview questions, b) the categorization task, and c) the forced-response interview questions. Children’s total scores were calculated through the analysis described in Chapter 4, section 4.8.1 (p. 98).

8.2.1 Findings

8.2.1.1 Results from the semi-structured interview questions

The children were awarded marks for their ability to provide scientifically acceptable criteria for living things (Chapter 4, section 4.8.1). Marks were given based on the complexity of the scientific criteria and a graph was produced (Table 8.8 and Figure 8.1). Figure 8.1 shows that there was an increase from a mean score of 1 to a mean score of 3 from Primary 1 to Primary 3. This result was expected because the children learn about these concepts in school. The mean score, however, dropped to 2 for Primary 4 children, when only English responses were accepted, before it climbed back to 3 for Primary 5 and Primary 6. This indicates that from Primary 3 onwards, as the age and the primary level increased, there was no improvement in the total mean scores on the semi-structured interview about living and non-living things.

As documented earlier, ‘animal’ was the most frequently cited example of a living thing by all children from different primary levels (Table 8.1). The results of the
next part of the interview, the categorization task, further explores whether children’s conceptions of ‘living thing’ is restricted to animals.

Table 8.8 *Descriptive statistical data of children’s total scores on their use of scientifically acceptable criteria for living in the semi-structured interview.*

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>15</td>
<td>1</td>
<td>.70</td>
</tr>
<tr>
<td>Primary 3</td>
<td>15</td>
<td>3</td>
<td>1.44</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>15</td>
<td>2</td>
<td>1.58</td>
</tr>
<tr>
<td>Primary 5</td>
<td>15</td>
<td>3</td>
<td>1.77</td>
</tr>
<tr>
<td>Primary 6</td>
<td>15</td>
<td>3</td>
<td>2.34</td>
</tr>
</tbody>
</table>

![Graph](image)

*Primary level*

*Figure 8.1 Children’s total scores awarded for the use of scientifically acceptable criteria for living in the semi-structured interview with English responses in Primary 4, 5 and 6.*
8.2.1.2 Results of the categorization task

Results of children’s mean scores on the categorization task are shown in Table 8.9 and Figure 8.2. The total possible score was 10. The results of this part of the interview indicate that the mean scores increased from 7.1 to 8.5 between Primary 1 and Primary 3. This change was, however, not significant (p = 0.11). The mean score for Primary 4 was similar to Primary 3 and there was a drop in the mean score in Primary 5. This difference was again not significant (p = 0.84). There was an improvement in the mean scores from Primary 5 to Primary 6, however, the mean was still lower than Primary 3 and Primary 4. If the change in language of instruction influenced the children’s understanding, it would be expected that a drop in the mean score would have occurred in Primary 4, not Primary 5. Nevertheless, things did not improve at all after Primary 3. This data, therefore, suggest that the change in language of instruction may have restricted the expected improvement in children’s ability to classify things as living or not living with age.

Table 8.9 Descriptive statistical data of children’s correct answers on the categorization task.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>15</td>
<td>7.13</td>
<td>1.24</td>
</tr>
<tr>
<td>Primary 3</td>
<td>15</td>
<td>8.53</td>
<td>1.18</td>
</tr>
<tr>
<td>Change of medium of instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 4</td>
<td>15</td>
<td>8.53</td>
<td>1.45</td>
</tr>
<tr>
<td>Primary 5</td>
<td>15</td>
<td>7.93</td>
<td>1.43</td>
</tr>
<tr>
<td>Primary 6</td>
<td>15</td>
<td>8.40</td>
<td>1.50</td>
</tr>
</tbody>
</table>
Figure 8.2 Children’s correct scores on the categorization task.

Table 8.10 and Figure 8.3 provide more detailed information about how the children in each primary level classified the pictures. Nearly all of the participants correctly identified a person, cat and bird as living and a majority also identified a table as not living. There were, however, inconsistent patterns of responses from the children when identifying a fire, car, plant, television and cloud as living or not. Table 8.10 shows that 21 children (28%) across the primary levels identified a fire as living. Even the upper primary children (Primary 4, 5 and 6) seemed to be unsure about this item. Almost half the children interviewed thought that a car was living (46%). This misconception was evenly spread throughout the primary levels with 7 of the 15 children interviewed in each of Primary 4, 5 and 6 indicating that a car is living.
Table 8.10 *Numbers of children who identified the instances as living in the categorization task.*

<table>
<thead>
<tr>
<th>Primary level</th>
<th>Fire</th>
<th>Table</th>
<th>Car</th>
<th>Person</th>
<th>Plant</th>
<th>Cat</th>
<th>Television</th>
<th>Cloud</th>
<th>House</th>
<th>Bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n=15)</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>13</td>
<td>2</td>
<td>15</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>3 (n=15)</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>14</td>
<td>10</td>
<td>15</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

Change of medium of instruction

<table>
<thead>
<tr>
<th>Primary level</th>
<th>Fire</th>
<th>Table</th>
<th>Car</th>
<th>Person</th>
<th>Plant</th>
<th>Cat</th>
<th>Television</th>
<th>Cloud</th>
<th>House</th>
<th>Bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (n=15)</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>5 (n=15)</td>
<td>8</td>
<td>0</td>
<td>7</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>6 (n=15)</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td>12</td>
<td>15</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Total (n=75)</td>
<td>21</td>
<td>1</td>
<td>35</td>
<td>71</td>
<td>47</td>
<td>75</td>
<td>14</td>
<td>34</td>
<td>4</td>
<td>74</td>
</tr>
</tbody>
</table>

(28%) (46%) (18.6%) (45.3%)
Figure 8.3 The number of children who identified the instances as living in the categorization task.
The significant number of children who categorized a car and a fire as living can possibly be attributed to the confusion between everyday and scientific meanings of the term animal as proposed by Bell (1981). In Malay, the phrases “start the engine (of the car)” and “to light the fire” are translated as “hidupkan kereta itu” and “hidupkan api itu” respectively. The word ‘hidup’ as used in the two phrases, if directly translated back into English, means ‘alive’. It appears that these children might be confused by the meaning of the word ‘hidup’ such that they thought that a car (kereta) and a fire (api), both are ‘living’.

Many of the children interviewed also thought that a television and a cloud are living (18.6% and 45.3% of the children, respectively). When asked why they classified these things as living, children seemed to cite the characteristic of ‘movement’ as the main reason, for example “ia hidup sebab ia bergerak” (It is alive because it is moving). This is perhaps not surprising as ‘movement’ is an important scientific criterion for categorizing living and one that is frequently used by children (Piaget, 1979). For example, all children (except one) categorized a cat and a bird as living because a cat and a bird appeared to be able to ‘move’ in some way. Similarly and in contrast with previous data, the majority of the children also correctly considered a person as living. In categorizing a cloud as living, two children used criteria other than movement:

“Ia hidup kerana is berubah warna dari putih kewarna hitam. Kalau hari hujan, awan akan jadi hitam.”

“It is living because it changes colour from white to black. If it is going to rain, the cloud will change to black.” (child #1, P3)

“A cloud is living because it makes (causes) the rain. It ‘controls’ the amount of rain.” (child #2, P6)

The results of the categorization task shown in Table 8.10 and Figure 8.3 indicate that age has a significant correlation with children’s perception of plants. More older children, from age 9 (Primary 3) onwards, tended to consider a plant to be living compared with the younger children. The majority of Primary 1 children (between 6 and 7 years old) (86.6%) thought that a plant is not living. When asked,
these children said that a plant is not living because it can not move or eat. From Primary 3 onwards, or when the children were eight years old and above, a greater proportion of the children considered plants to be alive. The reasons they used for plants being alive were that ‘plants grow’, ‘plants move’, ‘plants need food’, ‘plants breath’, ‘plants reproduce’ and ‘plants die’. The results, therefore, suggest that between the ages of 8 and 9 years there is a significant change in the children’s conceptions of plants from non-living to living things.

It is interesting to note that these results correlate with Carey’s study, but with children about one to two years younger. In Carey’s study, only by age 10 did the majority of children judge plants to be alive. In this study, conducted in Brunei, there was an earlier significant change in the conceptions of plants from non-living to living for children aged between 8 and 9 years. This result confirms research conducted by Tema (1989) and Villabi and Lucas (1991) who found that children who used languages other than English had a better scientific understanding of living at an earlier age. These data suggest that this advantage continued through the language transition with just as many Primary 4 children identifying plants as living things as Primary 3 children.

8.2.1.3 Results from the forced-response interview questions

Table 8.11 shows the children’s mean scores on the Likert scale items by primary level. It is clear that there was a significant increase from a mean score of 68 to a mean score of 91 from Primary 1 to Primary 3. This score was maintained through the language transition with a mean score of 92 for Primary 4. The mean score for Primary 5 children was a surprising 77, slightly higher than Primary 1 but much lower than that of Primary 3 and 4. Primary 6 children had a marginal higher mean score compared with Primary 3 of 95. At a surface level, the results may initially suggest that Primary 5 children performed at a lower level compared with what would be expected. However, with a sample of 15 children this poor performance may be due to that specific sample. The important, more holistic view of the results clearly is that beyond Primary 3, the progress of the pupils was minimal.

A one-way ANOVA (Table 8.12) showed significant differences in the means on the forced-response section of the interview for children at different primary levels,
\( F(44,30) = 2.04, p < .005 \). The difference was small, yet significant, with Cohen’s effect size = 0.16. Scheffe’s tests (Table 8.13), however, indicated that the significant differences lie only between Primary 1 and Primary 3, Primary 1 and Primary 4 and Primary 1 and Primary 6. This statistical analysis supports the assertion that the most appropriate conclusion to make is that progress beyond Primary 3 was minimal.

Table 8.11 Descriptive statistical data by primary level on the living and non-living forced-response interview.

<table>
<thead>
<tr>
<th>Items 1-23</th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>15</td>
<td>68</td>
<td>18.39</td>
</tr>
<tr>
<td>Primary 3</td>
<td>15</td>
<td>91</td>
<td>16.47</td>
</tr>
</tbody>
</table>

Change of medium of instruction

| Primary 4 | 15| 92   | 24.44          |
| Primary 5 | 15| 77   | 23.85          |
| Primary 6 | 15| 95   | 8.87           |

Table 8.12 Analysis of variance on the living and non-living forced-response interview using one-way ANOVA.

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIVING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>166.33</td>
<td>44</td>
<td>3.78</td>
<td>2.04</td>
<td>.02</td>
</tr>
<tr>
<td>Within groups</td>
<td>55.67</td>
<td>30</td>
<td>1.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>222.00</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8.13 *Multiple comparisons for significance across primary levels on the living and non-living forced response interview using Scheffé’s test.*

<table>
<thead>
<tr>
<th>(I) Level</th>
<th>(J) Level</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 1</td>
<td>Primary 3</td>
<td>-23.66</td>
<td>7.03</td>
<td>.03</td>
</tr>
<tr>
<td>Primary 1</td>
<td>Primary 4</td>
<td>-24.20</td>
<td>7.03</td>
<td>.03</td>
</tr>
<tr>
<td>Primary 1</td>
<td>Primary 5</td>
<td>-9.73</td>
<td>7.03</td>
<td>.75</td>
</tr>
<tr>
<td>Primary 1</td>
<td>Primary 6</td>
<td>-27.26</td>
<td>7.03</td>
<td>.01</td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 1</td>
<td>23.66</td>
<td>7.03</td>
<td>.03</td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 4</td>
<td>-5.53</td>
<td>7.03</td>
<td>1.00</td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 5</td>
<td>13.93</td>
<td>7.03</td>
<td>.42</td>
</tr>
<tr>
<td>Primary 3</td>
<td>Primary 6</td>
<td>-3.60</td>
<td>7.03</td>
<td>.99</td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 1</td>
<td>24.20</td>
<td>7.03</td>
<td>.03</td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 3</td>
<td>.53</td>
<td>7.03</td>
<td>1.00</td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 5</td>
<td>14.46</td>
<td>7.03</td>
<td>.38</td>
</tr>
<tr>
<td>Primary 4</td>
<td>Primary 6</td>
<td>-3.06</td>
<td>7.03</td>
<td>.99</td>
</tr>
<tr>
<td>Primary 5</td>
<td>Primary 1</td>
<td>9.73</td>
<td>7.03</td>
<td>.75</td>
</tr>
<tr>
<td>Primary 5</td>
<td>Primary 3</td>
<td>-13.93</td>
<td>7.03</td>
<td>.42</td>
</tr>
<tr>
<td>Primary 5</td>
<td>Primary 4</td>
<td>-14.46</td>
<td>7.03</td>
<td>.38</td>
</tr>
<tr>
<td>Primary 5</td>
<td>Primary 6</td>
<td>-17.53</td>
<td>7.03</td>
<td>.19</td>
</tr>
<tr>
<td>Primary 6</td>
<td>Primary 1</td>
<td>27.26</td>
<td>7.03</td>
<td>.01</td>
</tr>
<tr>
<td>Primary 6</td>
<td>Primary 3</td>
<td>3.60</td>
<td>7.03</td>
<td>.99</td>
</tr>
<tr>
<td>Primary 6</td>
<td>Primary 4</td>
<td>3.06</td>
<td>7.03</td>
<td>.99</td>
</tr>
<tr>
<td>Primary 6</td>
<td>Primary 5</td>
<td>17.53</td>
<td>7.03</td>
<td>.19</td>
</tr>
</tbody>
</table>

Even though there seemed to be a dramatic drop in the mean scores for Primary 5 children, the statistical analysis indicates the difference between Primary 4 and Primary 5 was not significant. Significant differences only exist between Primary 1 and all the other primary levels (Table 8.13 and Figure 8.4). The results of this test, therefore, indicate that between Primary 1 and Primary 3 children’s understanding of the concept of living changes significantly, but from Primary 3 onwards the development of understanding is too limited to be measured through this method.
Figure 8.4 Children's means scores on the forced-response interview about living and non-living things.

8.2.2 Conclusions

It would be expected that the Brunei children's understanding would continue to develop from Primary 3 to Primary 6 as they learn more about living and non-living things in school and in their everyday life. According to Vygotsky (1986), being able to learn a science concept in a formal educational setting should result in the acquisition of scientific concepts which should constitute a complex theory rather than simply spontaneous concepts that are acquired through social interaction. However, the results from the children's total scores on the semi-structured interview questions (Table 8.7), on the categorization task (Table 8.8) and on the forced-response interview (Table 8.10) indicate that this does not occur. The results certainly indicate an improvement in children's understanding from Primary 1 to Primary 3, as expected, but no improvement from then on. The inability of Brunei children to develop expected understandings of evaporation and condensation, concepts that are not taught in school (Chapter 6 & 7), perhaps served an early
indication that the pathway of learning science is complex for Brunei children. The analysis of the children's understandings of living and non-living things in this chapter verify that the use of the English language for instruction and in the interview clearly impacts on the children's comprehension and understanding of the items in the interview protocol.

8.3 Research Question 2c:

Do boys' and girls' conceptions of living things progress in the same way?

8.3.1 Findings

Analysis of data by gender on the three different sets of data including: a) total scores on the semi-structured interview questions, b) total scores on the categorization task and c) total scores on the forced-response interview questions yielded the results shown in Tables 8.14 and 8.15 and Figures 8.5, 8.6 and 8.7. ANOVA carried out on the data according to gender resulted in a significant outcome (Table 8.15) on all three sets of data. However, when Scheffe's test analyses were carried out to pinpoint the differences, no significant difference was found between males and females either between primary levels or within the primary levels.

8.3.2 Conclusions

These results suggest that gender does not disadvantage a child with regard to their conceptual understanding of the concept of living. Much research that has focused on factors that influence success in learning a second language has concluded that girls are better than boys (e.g. Hertel, 1996; Kaklke, 1996; Nyland, 2001). However, the results of this study indicate that even when Brunei children use the English language, boys' and girls' understanding of the science concept of living develop at the same rate.
Table 8.14 *Descriptive statistical data of study sample by gender on their understanding of the concept of living.*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s mean scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on the semi-structured interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (male)</td>
<td>6</td>
<td>1.17</td>
<td>.75</td>
</tr>
<tr>
<td>Primary 1 (female)</td>
<td>9</td>
<td>1.33</td>
<td>.70</td>
</tr>
<tr>
<td>Primary 3 (male)</td>
<td>9</td>
<td>2.22</td>
<td>1.09</td>
</tr>
<tr>
<td>Primary 3 (female)</td>
<td>6</td>
<td>3.50</td>
<td>1.64</td>
</tr>
<tr>
<td>Primary 4 (male)</td>
<td>8</td>
<td>1.37</td>
<td>1.50</td>
</tr>
<tr>
<td>Primary 4 (female)</td>
<td>7</td>
<td>2.57</td>
<td>1.51</td>
</tr>
<tr>
<td>Primary 5 (male)</td>
<td>7</td>
<td>3.28</td>
<td>2.21</td>
</tr>
<tr>
<td>Primary 5 (female)</td>
<td>8</td>
<td>1.87</td>
<td>.99</td>
</tr>
<tr>
<td>Primary 6 (male)</td>
<td>8</td>
<td>1.87</td>
<td>1.13</td>
</tr>
<tr>
<td>Primary 6 (female)</td>
<td>7</td>
<td>3.71</td>
<td>3.04</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>2.24</td>
<td>1.70</td>
</tr>
<tr>
<td>Children’s mean scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on categorization task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (female)</td>
<td>6</td>
<td>7.50</td>
<td>1.05</td>
</tr>
<tr>
<td>Primary 1 (female)</td>
<td>9</td>
<td>6.89</td>
<td>1.36</td>
</tr>
<tr>
<td>Primary 3 (male)</td>
<td>9</td>
<td>8.55</td>
<td>1.13</td>
</tr>
<tr>
<td>Primary 3 (female)</td>
<td>6</td>
<td>8.50</td>
<td>1.38</td>
</tr>
<tr>
<td>Primary 4 (male)</td>
<td>8</td>
<td>8.25</td>
<td>1.58</td>
</tr>
<tr>
<td>Primary 4 (female)</td>
<td>7</td>
<td>9.00</td>
<td>1.15</td>
</tr>
<tr>
<td>Primary 5 (male)</td>
<td>7</td>
<td>7.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Primary 5 (female)</td>
<td>8</td>
<td>8.75</td>
<td>1.28</td>
</tr>
<tr>
<td>Primary 6 (male)</td>
<td>8</td>
<td>8.87</td>
<td>1.36</td>
</tr>
<tr>
<td>Primary 6 (female)</td>
<td>7</td>
<td>7.86</td>
<td>1.57</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>8.12</td>
<td>1.43</td>
</tr>
<tr>
<td>Children’s mean scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on forced-response interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 1 (female)</td>
<td>6</td>
<td>58.00</td>
<td>25.45</td>
</tr>
<tr>
<td>Primary 1 (female)</td>
<td>9</td>
<td>74.22</td>
<td>8.27</td>
</tr>
<tr>
<td>Primary 3 (male)</td>
<td>9</td>
<td>94.44</td>
<td>12.25</td>
</tr>
<tr>
<td>Primary 3 (female)</td>
<td>6</td>
<td>86.83</td>
<td>21.85</td>
</tr>
<tr>
<td>Primary 4 (male)</td>
<td>8</td>
<td>88.87</td>
<td>30.90</td>
</tr>
<tr>
<td>Primary 4 (female)</td>
<td>7</td>
<td>95.43</td>
<td>15.92</td>
</tr>
<tr>
<td>Primary 5 (male)</td>
<td>7</td>
<td>78.00</td>
<td>26.44</td>
</tr>
<tr>
<td>Primary 5 (female)</td>
<td>8</td>
<td>77.00</td>
<td>23.19</td>
</tr>
<tr>
<td>Primary 6 (male)</td>
<td>8</td>
<td>92.87</td>
<td>8.53</td>
</tr>
<tr>
<td>Primary 6 (female)</td>
<td>7</td>
<td>97.43</td>
<td>9.27</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>84.71</td>
<td>21.47</td>
</tr>
</tbody>
</table>
Table 8.15 ANOVA results for boys' and girls' concepts of living and non-living.

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children's mean scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on the semi-structured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interviews</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>55.59</td>
<td>9</td>
<td>6.18</td>
<td>2.51</td>
<td>.02</td>
</tr>
<tr>
<td>Within groups</td>
<td>160.08</td>
<td>65</td>
<td>2.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>41.08</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children's mean scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on the categorization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>41.08</td>
<td>9</td>
<td>4.56</td>
<td>2.68</td>
<td>.01</td>
</tr>
<tr>
<td>Within groups</td>
<td>110.84</td>
<td>65</td>
<td>1.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>151.92</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children's mean scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on the forced-response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interviews</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>9549.75</td>
<td>9</td>
<td>1061.08</td>
<td>2.81</td>
<td>.01</td>
</tr>
<tr>
<td>Within groups</td>
<td>24561.79</td>
<td>65</td>
<td>377.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34111.54</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Graph](image)

**Figure 8.5** Boys' and girls' mean scores for their description of living in the semi-structured interviews.
**Figure 8.6** Boys’ and girls’ mean scores for the categorization task about living and non-living.

**Figure 8.7** Boys’ and girls’ mean scores on the forced-response interview about living and non-living.
8.4 Research Question 2d:

What are the ontological differences in the way that children understand the concepts of living and non-living things across the primary levels 1 – 6?

This research question was developed to provide an insight into the pathway of learning by analyzing children’s understandings through an ontological perspective of conceptual change. This investigation was addressed by three questions in the semi-structured interview:

- In what ways are these things (pictures of animals and plants) similar?
- In what ways are these things (pictures of animals and plants) different?
- Do you think these (pictures of animals and plants) are living or not-living?

8.4.1 Findings

8.4.1.1 Are plants living?

Children’s responses to the questions, “In what ways are these things (pictures of animals and plants) different?” and “Do you think these (pictures of animals and plants) are living or not-living?” have already been presented and discussed earlier in Research Question 2a (Table 8.6 and Table 8.5 respectively). For this research question, the same data are used again because the results are thought to be significant and relevant for Research Question 2d. The data are analysed differently, however, and for the question, “Do you think these (pictures of animals and plants) are living or not-living?”, the data are more detailed than previously presented in Table 8.6.

The children’s responses to the three questions used in this part of the interview are displayed in Tables 8.16, 8.17 (similar to Table 8.6 but the information is more detailed), and 8.5 and Figure 8.8. Two important results emerge from this data. The first concerns the Primary 1 children who clearly tended to think that plants are non-living things. The second finding concerns the older children. While many of these children thought of both animals and plants as living, they used different predicates
for plants and animals. Both these findings will be elaborated in the following paragraphs.

Table 8.16 *Children's responses to the question: “In what ways are these things (pictures of animals and plants) similar?”*

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1 (n = 15)</th>
<th>Primary 3 (n = 15)</th>
<th>Primary 4 (n = 15)</th>
<th>Primary 5 (n = 15)</th>
<th>Primary 6 (n = 15)</th>
<th>Total (n = 75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>15</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Both grow</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Both move</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Both need food</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Both need food and breathe</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Both grow and reproduce</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Both grow, die and need food</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Both move, grow and need food</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Both reproduce</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 8.17 Children’s responses to the question: “In what ways are these things (pictures of animals and plants) different?”

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Primary 1 (n = 15)</th>
<th>Primary 3 (n = 15)</th>
<th>Primary 4 (n = 15)</th>
<th>Primary 5 (n = 15)</th>
<th>Primary 6 (n = 15)</th>
<th>Total (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Animals move, plants don’t</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Animals need food, plants don’t</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Animals move and need food, plants don’t</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Animals breathe, plants don’t</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Animals move and breathe, plants don’t</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Animals move, need food and breathe, plants don’t</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Animals reproduce and have skeleton, plants don’t</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Their features are different</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Animals are living, plants are not</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>22</td>
</tr>
</tbody>
</table>
Figure 8.8 Pie charts showing the distribution of children’s responses for Primary 1, 3, 4, 5 and 6 to the question: ‘Do you think these (pictures of animals and plants) are living or not-living?’
As discussed previously, the data (Table 8.5 and Figure 8.8) show that none of the Primary 1 children thought that both plants and animals are living. When asked, “In what ways plants and animals are similar?”, 100% of the Primary 1 children gave no response (Table 8.16) indicating that they did not understand the question or they couldn’t think of any similarities. When asked in what ways they are different, 14 of the 15 children interviewed (93.3%) thought that animals are living and plants are not living (Table 8.17). The remaining child gave no response. From an ontological perspective, therefore, almost 100% of Primary 1 children thought it makes no sense to say ‘Plants are alive’. For these children, the statement ‘Plants are alive’ is a category mistake, because, for them it is merely false. These results indicate that in general, Primary 1 children lack the superordinate concept living thing. As a result, animals and plants are not assembled in a single ontological category of living thing and plants appear to be in a category which is ontologically distinct from living things and from animals.

The second finding concerning the older groups was quite intriguing because, on the one hand, it showed a sophisticated ontological grouping of plants and animals as living things. On the other hand, the results revealed the different ontological predicates the children applied to plants and animals. The majority of Primary 3, 4, 5 and 6 children (80%) aged between 8 and 12 years thought that both animals and plants are living (Table 8.5). Regardless of the fact that these older children considered plants alive, they did not attribute certain basic properties of living things to plants. In other words, they had the tendency to apply only to animals the predicates that adults and scientists apply to all living things. As shown in Table 8.17, when asked, ‘In what ways are these (pictures of animals and plants) different?’, 42 (70%) of Primary 3, 4, 5 and 6 children thought that plants do not move, need food, breathe or reproduce. These characteristics are the predicates that adults and scientists apply to living things yet, for these children, the predicates that something moves, needs food, breathes and reproduces only apply to animals and not to plants.

When asked, “In what ways are these things (pictures of animals and plants) similar?”, an extraordinary two-thirds of the Primary 3, 4, 5 and 6 children gave no response (Table 8.16). It is likely that these children were unsure, or completely
unaware of, the similarities between animals and plants even though they did consider that they belonged to the same living category. Some children did identify growth (13, Table 8.16), movement (2, Table 8.16), need food (1, Table 8.16), and other characteristics as similar between plants and animals. When further questioned about differences, 19 children from Primary 3, 4, 5 and 6 (Table 8.17) gave no response and a similar proportion of children (22, Table 8.17) said animals are living and plants are not.

8.4.1.2 Predicates of living things

Table 8.18 (adapted from Table 8.17) shows the clusters of predicates that the children in the respective primary levels thought applied only to animals (Primary 1 is not included in this table because none of these children mentioned predicates of living things). These children provided these responses when they were asked the differences between animals and plants. The results indicate that a considerable proportion of Primary 5 and 6 children aged between 10 and 12 years thought that plants do not move, need food, breathe or reproduce. This pattern was rarely seen among 8-year-olds and never among 9-year-olds or adults investigated in Carey’s (1985) study. It follows that while the majority of the children associated predicates of living things only with animals, for example, “animals move but plants don’t”, the remaining group either gave no response or immediately identified plants as not living. It is, therefore, unclear whether it was the children who thought plants are not living, who applied the predicates of living things only to animals.

Table 8.18 shows that while a considerable number of Primary 3, 5 and 6 children made sensible associations with animals’ biological properties, such as they move, need food, breathe and reproduce, none of the Primary 4 children were found to associate the predicates of living things with animals other than ‘movement’. Seven Primary 4 children, or the majority, preferred not to give an answer to the question. Six of them said that animals move but plants do not. One mentioned a non-scientifically acceptable reason that animals have eyes. Finally, the remaining child simply said that animals are living and plants are not. These patterns point to three possibilities. First, the Primary 4 children might not have had any idea of the differences between animals and plants other than the perceived idea that animals
move and plants do not. Second, it might be possible, however, that they had ideas that would differentiate between animals and plants, but they could not produce the words in the language in which they were interviewed. Third, it may be possible that the Primary 4 children were able to group animals and plants in a single ontological category of living but not recognize the differences (except that plants do not move).

Table 8.18 Number of children who restricted predicates of living things to just animals when asked the differences between plants and animals.

<table>
<thead>
<tr>
<th>Predicates</th>
<th>Primary 3 (n = 15)</th>
<th>Primary 4 (n = 15)</th>
<th>Primary 5 (n = 15)</th>
<th>Primary 6 (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>5</td>
<td>7 (46.6%)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Move</td>
<td>4 (27%)</td>
<td>6 (40%)</td>
<td>7 (47%)</td>
<td>4 (27%)</td>
</tr>
<tr>
<td>Need food</td>
<td>1 (7%)</td>
<td>0</td>
<td>4 (27%)</td>
<td>4 (27%)</td>
</tr>
<tr>
<td>Breathe</td>
<td>1 (7%)</td>
<td>0</td>
<td>2 (13%)</td>
<td>2 (13%)</td>
</tr>
<tr>
<td>Reproduce</td>
<td>0</td>
<td>0</td>
<td>1 (7%)</td>
<td>0</td>
</tr>
</tbody>
</table>

It is intriguing to note that half (46.6%, Table 8.18) the Primary 4 children chose not to communicate their ideas. The number of children who did not respond to this question, interestingly, decreased to 5 Primary 5 children and only 1 Primary 6 child. Considering that the change of medium of instruction happens when the children are in Primary 4 and that the language of interview was English for Primary 4 onwards, it is likely that the Primary 4 children did not give an answer because they were not able to convey their ideas in English. As Primary 5 and Primary 6 children were more confident with English, more children did respond.

When asked for the similarities between animals and plants, 66% of Primary 3, 54% of Primary 4, 40% of Primary 5 and 75% of Primary 6 children had a tendency to concur with the predicates that adults would apply to living things (Table 8.19, adapted from Table 8.16). (Primary 1 children are purposely omitted from the table because none of the Primary 1 children responded to the question). From Table 8.19, it can be seen that the predicates that the children thought could be used for both animals and plants were 'move', 'grow', 'need food', 'breathe' and 'reproduce'. It
follows that the children who used these predicates recognized that plants and animals share the same biological properties. It is important to note that there was a drop in the percentage of children who could identify similarities between Primary 3 and Primary 4. More Primary 3 children (66%) used scientific predicates for living things than Primary 4 (only 54%) (Table 8.19). Considering the Primary 4 children were interviewed in English, it is likely that the children had limited words in English to explain the predicates shared between the animals and plants.

Table 8.19 Number of children who agreed that the predicates used for animals also can be used for plants.

<table>
<thead>
<tr>
<th>Predicates</th>
<th>Primary 3</th>
<th>Primary 4</th>
<th>Primary 5</th>
<th>Primary 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>9 (60%)</td>
<td>9 (60%)</td>
<td>11 (73.3%)</td>
<td>6 (40%)</td>
</tr>
<tr>
<td>Move</td>
<td>2 (13%)</td>
<td>0</td>
<td>1 (7%)</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>Grow</td>
<td>5 (33%)</td>
<td>4 (27%)</td>
<td>3 (20%)</td>
<td>7 (47%)</td>
</tr>
<tr>
<td>Need food</td>
<td>2 (13%)</td>
<td>3 (20%)</td>
<td>0</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>Breathe</td>
<td>0</td>
<td>1 (7%)</td>
<td>0</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>Reproduce</td>
<td>1 (7%)</td>
<td>0</td>
<td>2 (13%)</td>
<td>1 (7%)</td>
</tr>
</tbody>
</table>

While some of the children were aware that plants have at least some properties in common with animals (Table 8.19), other children continued to restrict the properties of living things to animals only (Table 8.18). Even some of the children in Primary 6 may not have developed a superordinate concept of living things. Some Primary 6 children considered the idea that 'plants move' a category mistake. Hence, not only did the children lack the superordinate concept living thing, they also tended to regard plants as an ontologically distinct category which does not share the properties of living things with animals. Moreover, these Primary 6 children also considered plants and animals as two ontologically distinct categories because animals need food and breathe whereas plants do not. There was 1 Primary 5 child who thought it a category mistake to associate the predicate 'reproduce' to plants. Interestingly, however, none of Primary 3, 4, 5 and 6 children thought that it was a category mistake to associate plants with the predicate 'grow' (Table 8.18). In
fact, the majority of children in each primary level (Table 8.19) agreed that the predicate ‘grow’ used for animals also can be used for plants. The predicates ‘movement’, ‘the need for food’, ‘breathing’ and ‘reproduction’ were rarely seen as being common to plants and animals in all levels. A possible reason why the predicate ‘grow’ was the most commonly used could be that the activity of growing is very perceptible to children. It is likely that the predicates ‘move’, ‘need food’, ‘breathe’ and ‘reproduce’ could not easily be observed by the children. There is no notable difference between Primary 3 and 4 when the language of instruction and the language of the interviewer changed to English.

A point worth considering is that children’s responses to the two questions, ‘Do you think these (pictures of animals and plants) are living or not-living?’ and ‘In what ways are these things (pictures of animals and plants) different?’ have shown an interesting pattern of understanding about the concept of living. The majority of Primary 3, 4, 5 and 6 thought that both animals and plants are living (Table 8.5). Yet, when asked ‘In what ways are plants and animals different?’, there was a considerable number of these children who used the scientific predicates of living things only for animals (Table 8.17). It seems that from Primary 3 (8 years of age) onwards, children are already able to subsume animals and plants as living things. This pattern is consistent with Carey’s (1985) finding but with children at least 2 years older. However, at the same time, the children also were shown to have an understanding that animals and plants do not share similar characteristics. It follows that while these children recognized the superordinate concept of living things consists of animals and plants, these children classified animals and plants as two separate ontological categories, each with different sets of predicates.

8.4.1.3 Summary of children’s conceptions of living and non-living from an ontological perspective

Figure 8.9 represents the ontological intuitions of all children interviewed in this study about the characteristics of animals and plants. The structure of the ontologically basic concepts built by the children, even though very simple, provide a backbone for answering this research question. Conventions for reading the tree are as follows: Concepts are in upper-case letters, predicates in lower-case letters.
Broken lines indicate concept-predicate combinations, which are not scientifically appropriate, yet some children thought that they were. Thus, for some children 'living things' covered all the predicates 'move', 'need food', 'breathe', 'grow', 'reproduce', 'die' and 'need water'. Other children thought that plants are non-living things and that they spanned all of the predicates 'do not move', 'do not need food', 'do not breathe' and 'do not reproduce'. The last group of children thought that plants are living things yet did not possess the predicates 'move', 'need food', 'breathe' and 'reproduce'.

![Diagram showing concept-predicate combinations for living and non-living things.](image)

Figure 8.9 A generic representation of the children's ontological conceptions of the concepts of living and non-living things.

8.4.2 Conclusions

This section of this research investigated the ontological differences in children's understanding of the concepts living and not living through the primary years. The findings are similar to previous sections in this chapter that presented data about Brunei children's naïve conceptions and the development of their understandings. It also became evident in this section that the younger children failed to recognise plants as living things. What is unique about this section of the research is that the ontological analysis applied to the data revealed more in-depth and revealing information about the older children's understanding of these concepts.
A revealing outcome of this ontological analysis was the presence of a gap between children's tendency to judge animals and plants as alive and their realization of the superordinate category living thing. These children may have understood that animals and plants are living but they (animals and plants) may not necessarily have similar biological properties. The children, who clearly did not display the adult patterns of understanding about the concept living, may have mapped the word 'alive' onto their understanding of both animals and plants. However, it seems that they based their classification not on the similar ontological categories that animals and plants share, but on something which is not clear. To the children, animals are living because they breathe. On the other hand, children understood that plants are also living even though, in the children's mind, they do not breathe. It is not clear, therefore, how children are able to classify plants as living if, at the same time, they fail to associate the characteristics of living things with plants.

Further analysis of children's responses divulged important information with regard to the language transition. Despite being relatively easy questions, Primary 4 children typically were less likely to respond compared with Primary 3 children. This finding perhaps indicates that many of the children who did not respond simply did not understand the questions that were posed in English. Consequently, this study suggests the possibility that the effect of the language transition is to silence some children.

8.5 General Conclusions and Discussions

The patterns of development of children's understanding of living and non-living things with age found in this study are not consistent with the trend formulated by Carey (1985). From both a developmental and an ontological perspective of conceptual change, the children in this research made considerable headway in understanding the cluster of concepts of living and non-living things from Primary 1 to Primary 3, there was, however, no improvement from Primary 4 onwards. There are three issues of significance that emerge from findings. These issues of significance are summarized in the following paragraphs under the headings alternative conceptions, language confusion and animals and plants as two separate ontological categories.
1. Alternative Conceptions

Carey (1985) points out that the young child does not represent the concept living things with the same extension as the adult. None of the 4 to 7 year old children in Carey’s study judged all animals and plants to be alive. The results of this part of the investigation seemed to be consistent with Carey’s findings. This study indicates that young Brunei children did not represent the concept of living thing in the same way as adults because the majority did not consider plants to be living. Only by the age 10 did children in Carey’s study judge animals and plants to be alive. In this case, however, there was a considerable number of older Brunei children, aged between 11 and 12 years, who were found to consider plants as non-living things.

The children in this study also appeared to operate with a concept of living that is similar to the frameworks used by biologists. This is because the children tended not to use non-scientific criteria as frequently as children reported in other studies (Venville, 2004). The children were not restricted to scientific categories during the interviews, yet the children’s common understanding and explanations of living tended to focus on the criterion of movement. Thus, superficially, the children seemed to have a good conception of the concept of living because they could associate ‘movement’ with ‘being alive’ and movement is a scientifically acceptable criterion for life. However, at a deeper level, this was not the case. When asked to judge whether the ten phenomena in the categorization task were living or not, many children thought that ‘self-starters’ (Piaget, 1979) such as fire and clouds and other things like the car and television were living because these things are observed by children to move. Moreover, things that are living, for example plants that are not easily observed to move, were categorized by many children as not living.

It has also been shown that the children in this study understood that living things could be identified through the use of criteria such as movement and nutrition (Table 8.1). Even though these criteria are not unique to animals, the children seemed to perceive that plants did not possess these characteristics, thus making it difficult for them to classify plants as living.
2. Language Confusion

The broad quantitative analysis and presentation of the data for this section of this research indicate that the children's understand of the concepts living and non-living was impeded between Primary 3 and Primary 4. The qualitative analysis and examination of the data demonstrated that language was observed to create some difficulty and/or confusion for children in relation to their understanding of these concepts. The confusion between the everyday and scientific meanings of the word 'living' in English appeared to be a problem for the children in Brunei whose home language is Malay (Bell, 1981). The use of the English word 'living' in a scientific context in Brunei classrooms is likely to create a great deal of difficulty for those students who understand the everyday aspects of the word that relates to living 'in a house or home'. Moreover, idiosyncratic aspects of the Brunei Malay language, for example that 'hidup' means 'turn on' but is directly translated in English to mean 'alive', also may precipitate misconceptions that a car and television are living. The majority of these misconceptions seemed to be perpetuated from lower primary to upper primary school. Coupled with low levels of English language vocabulary acquisition and fluency, these misconceptions are unlikely to be readily addressed through classroom instruction.

3. Animals and plants as two separate ontological categories

A further issue of significance relates to the children's idea that animals and plants are two separate ontological categories. Apart from indicating a generally satisfactory level of thinking displayed by the older children that plants are living things, they also demonstrated a significant amount of understanding that plants do not share the same biological properties as animals. It is, therefore, not easy to interpret from the children's thinking of what might prompt them to categorize plants as living.

Arguments in the dilemma of Brunei children having to learn science in a second language are, of course, not restricted to those concerned with learning outcomes. They also include reference to other factors such as method of teaching and questioning techniques both in classroom and during tests and examinations. In an
attempt to highlight the important possible tasks to be tackled, related issues are drawn together in the next chapter.
CHAPTER NINE

CONCLUSIONS AND IMPLICATIONS

9.0 Introduction

The previous three chapters presented critical discussion within the theoretical framework of this study that addressed each of the research questions. The discussion was augmented through a consideration of relevant previous research. Being the first research of its kind in Brunei, this study has enabled important insights into pertinent issues resulting from the priorities and policies of the Brunei Ministry of Education. This chapter draws together the findings from each of the chapters and discusses the implications for the Brunei system of education. The discussion of the general conclusions, however, needs as its prerequisite the reiteration of the important aspects of each of the previous chapters.

9.1 Overview of Important Aspects of Previous Chapters

This study, which focused on the influence of change in language of instruction on children’s conceptual development, emerged from a larger scope of rationales. Chapter 1 outlined the underlying rationales that initiated this study, such as the influence of language on science learning and the Brunei Government’s bilingual policy. The scope of the research was narrowed to a set of research questions, presented in Chapter 1, that were critically formulated to guide the researcher throughout this study. It was forecast in Chapter 1 that this study would make a considerable contribution to research in the areas of bilingual education, particularly in Brunei, and children’s development of understanding in science. As the study developed and data were collected, findings were organized into several chapters. The first chapter was written as an overview and cognitive organizer for the subsequent chapters.

Chapter 2 unfolds the Brunei Government’s desire to take a global view of communication. Today’s Brunei education system has been moulded into what is
referred to as the ‘Bruneians’ way’, that is, for people to be competent in both Malay and English languages. With an inception in 1985, the Education Ministry commenced a policy of instruction in both languages. Generally, bilingualism has been regarded as beneficial. At the very least, it serves to lessen discontinuities between home and school for children in Brunei. The choice of English as the other language is obvious as it is a major world-wide language of communication. Whether they like it or not, acquiring a sufficient standard in a second language is an advantage for Brunei people. The requirements for higher education and the benefits for the development of one’s career demonstrate the positive attributes of bilingualism. While ‘Bahasa Melayu’ or the Malay language reflects the identity of Bruneians, English language is seen as the language of global communication.

Bilingualism has now been implemented for almost two decades and Brunei education authorities have recently noted indications of the underachievement of a large percentage of pupils in science. The success of the country’s new education system was, therefore, brought under question. One issue that became apparent was the need to gather information on the learning of science in classrooms which became the driving principle of this study. Two clusters of science concepts were chosen as the context to examine children’s learning in science and the influence that the bilingual language policy has on that process. The first cluster of concepts related to evaporation and condensation and the second cluster of concepts related to living and non-living things. Under the bilingual language policy, Malay is used to teach various subjects, including science, at the lower primary level. A sudden switch from Malay to English as the language of instruction in these subjects occurs when the children move to the upper primary level.

Chapter 3 provided an in-depth examination of the previous research on student learning of the concepts of evaporation and condensation and the concepts of living and non-living things. The literature indicated that older children displayed a surer sense of understanding of the concepts of evaporation and condensation than younger children. With ample vocabulary, older children were found to be able to use appropriate words to link their ideas and thus to produce sensible explanations for evaporation and condensation. Therefore, even though children were generally observed to move towards a more sophisticated view of evaporation and
condensation with increasing age, the pathway was said to be complex as it was fashioned by their ability to use appropriate language in describing the phenomena.

The results from previous studies also demonstrated that language may have a critical influence on the development of students' understanding of the concepts of living and non-living things and the subsidiary concepts of animal and plant. In particular, it was noted that in at least two studies (Tema, 1989, Villalbi & Lucas, 1991) students had a more scientific concept of living at an earlier age when interviewed in their indigenous language compared with English speaking students. It was concluded that there may be aspects of the English language that problematise the learning of this and related scientific concepts. The literature provides evidence of a trend towards greater understanding of the concept of living as children grow older. The literature suggests that the realization of the superordinate concept of living thing is assisted by the ability of children to consider the predicates of both animals and plants. At the very least, the better children explain the predicates for both animals and plants, the better their understanding of the concept of living. Consequently, this study considered linguistic subtleties apparent in the bilingual system of education that Brunei employs which are crucial in pupils' understanding of science.

The theoretical framework was constructed within the paradigm of constructivism and developed around five important aspects. These five aspects included: 1) the clusters of science concepts investigated, 2) issues of language, 3) conceptual development, and conceptual change from both 4) epistemological and 5) ontological perspectives. These two conceptual change perspectives were used as the basis for analysing what might count as evidence for conceptual change in several previous studies. The development of this theoretical framework was crucial in establishing the essence of the study. Not only did it guide the development of the research questions and impact on the method, it also provided several lenses through which the data were analysed.

The most immediate consequence of the development of the theoretical framework was the methodology presented in Chapter 4. In particular, this chapter focussed on the research approach that was implemented in an endeavour to obtain concrete and reliable data. Two cross sectional case studies were employed as the research
design: 1) Case Study 1: The concepts of evaporation and condensation, and 2) Case Study 2: The concepts of living and non-living things. The majority of data were collected through semi-structured and forced-response interviews.

An aspect of the method which often enhances the validity and reliability of an instrument is the administration of a pilot test. The newly developed interview protocols for this study were, therefore, tested and amended accordingly before they were used in the main study. Chapter 5 elaborated further on these pilot studies.

The first results of this study, that is, Brunei children's understanding of evaporation and condensation were presented in Chapter 6. The children's understandings of this concept at different ages were found to be complex and the existence of stages of development that were apparent in previous research were not clearly evident. The findings presented in Chapter 6 demonstrated that the children's manner of explaining these phenomena was influenced by their culture. Moreover, the data demonstrated that Primary 4 pupils' choice of explanations of water, evaporation and condensation items on a Likert scale written in English were less sophisticated than Primary 3 and Primary 1 pupils' choice of explanations on the same Likert scale written in Malay. This kind of underachievement is undoubtedly, important and clearly a result of the change of language of instruction. Under the bilingual system of education, Primary 4 pupils, who are taught in English, are disadvantaged because they have poor comprehension and lack the vocabulary necessary for discussion in English. Hence, learning and expressing understanding about science concepts such as evaporation and condensation is hampered in the primary school years when the English language is first introduced as the language of instruction.

Results presented in Chapter 7 provide evidence for conceptual change with regard to the concepts of evaporation and condensation. It was found that the transfer of language as the children progressed from Primary 3 to Primary 4 negatively influenced the development of children's ontological conceptions. Similarly, there was evidence that the use of the English language hampered the ability of children to express their explanations on the phenomena thus influencing the status of the children’s conceptions. Equally of interest, this chapter presented evidence that an increase in status of conceptions from an epistemological perspective does not necessarily correlate with an increase in sophistication of conceptual understanding.
from an ontological perspective. The evidence presented in this chapter further demonstrated that the majority of pupils had limited proficiency in the English language and that this is a factor that inhibits the process of conceptual change.

Chapter 8 reported on children's understanding of living and non-living things from developmental and ontological perspectives. Unlike the concepts of evaporation and condensation, the concept of living is taught at all levels in the Brunei school curriculum. Children in this study were found to bring a significant number of alternative conceptions about the concept of living to school, a pattern consistent with trends in previous research. However, the results indicated that there was an inconsistent pattern of development of understanding of living with an increase in age. The change from Malay to English from Primary 3 to 4 seemed to hamper children's manner of explaining the concept of living. A similarity in the patterns of development of understanding about the concepts of evaporation and condensation and the concept of living things was, therefore, observed. Further analysis also found that more Primary 4 children did not respond to interview questions compared with Primary 3 children. This suggests that one important effect of the language transfer at this age was to silence some children. It is not unusual in Brunei for young children to say nothing, particularly when asked questions of which they are not sure of the answer. They avoid speaking by using gestures and facial expressions. Another interesting finding that the data presented in this chapter divulged was that the capability of children to judge animals and plants as alive does not necessarily mean that they really understand that animals and plants share the same biological properties.

9.2 General Conclusions

In the last 18 years, since Brunei Darussalam adopted the new school curriculum that incorporates two languages, heightened interest in the academic performance of students has resulted in the analysis of the system from different perspectives. For example, there has been interest not only in the pupils' language development, but in the development of their scientific understandings and mathematical knowledge. This study does not provide a definitive explanation of the overall picture of the system. However, as far as the learning of science is concerned, the findings may
provide some explanations for the trend towards pupils lacking formal qualifications in the science subjects necessary to get places in university science courses.

This study focussed on the question of the influence of change in language of instruction on the development of children’s conceptual understanding of evaporation and condensation and living and non-living things. The discussion that follows examines how the findings of this study contribute to the debate about whether proficiency in the English language is more important than primary pupils learning science (details of this debate were outlined earlier in Chapter 3, section 3.1, p. 39) and considers implications for practice and future research.

Patterns of conceptual development about evaporation and condensation and living and non-living things

The Brunei children’s patterns of understanding of evaporation and condensation did not follow the typical age-related pathway projected by previous research that shows a positive correlation between increase in age and more sophisticated views of these concepts. Similarly, the children in this study were not observed to follow the projected pathway of development when asked to explain the concepts of living and non-living things. This finding supports the diagrammatic hypothesis presented in Chapter 1 (Figure 1.1, p. 6). In this diagram an ideal pathway was drawn to represent the positive development of understanding from Primary 1 to Primary 6 that reflected previous research and a possible pathway was drawn to represent an alternative pattern of development of understanding which does not follow the ideal trend. The patterns of understanding observed in this study more closely followed the possible pathway than the ideal pathway. The analysis of the data supporting this finding is presented in Chapter 8, section 8.2.2, p. 238 – 239.

The influence of language transfer on the development of children’s understanding of selected scientific concepts

The pattern of development of children’s understanding of science concepts observed in this study is important because their ability to express their understanding was hampered by the change of language from Malay to English. The effect of the language transition was found to hinder children’s ways of explaining
and expressing ideas and to result in some children not speaking at all when they were asked questions about their understanding of selected science concepts. Children’s poor explanations were observed to be initiated and/or supported by three factors: a) a narrow view of questions and answers, b) poor vocabulary, and c) a lack of language discipline. These factors are explained in the subsequent sections.

*Narrow view of question and answers (classroom culture)*

The particular classroom culture that the researcher observed in the Brunei schools might have influenced the children’s way of dealing with questions. Most of the time, the Primary 1, 3, 4, 5 and 6 teachers posed closed questions. The answers expected were either ‘yes’ or ‘no’ or other one-word answers. As a result, some of these children may have a limited understanding of viewing and interpreting questions, such that, when asked, it is acceptable to simply guess the answer without thinking. Consequently, children had difficulty when later asked questions that required them to discuss information about which they were not confident. If this was the case, it is not surprising that the children simply ignored the interview questions or, at the very least, provided explanations that were merely perceptual descriptions.

*Poor vocabulary*

In the course of this study, the researcher observed the existence of what has been described as a symbiotic relationship between English and Malay in the classrooms (Martin, 1999), where one language supported the other. In most situations, this happened when upper primary children did not understand words expressed in English. To mediate the meanings, teachers explained the words in Malay. In other situations, children were confused by the everyday and scientific meanings of some English words, for example, the word ‘living’. These scenarios demonstrated the extent to which the children’s English vocabulary was limited. Obviously, limited word provision in English is likely to have contributed to the generation of poor explanations in that language. Furthermore, the lack of communication may have been exacerbated when children were asked to explain the phenomena of evaporation and condensation about the scenarios the children were not familiar with. Similarly, for the concepts of living and non-living, the availability of English
vocabulary that they were exposed to during their science classes may not have been sufficient enough for them to feel comfortable when describing the concepts in English. The observed patterns of understanding about living and non-living things at least did not regress as did their understanding of evaporation and condensation. Yet, the observation that the children did not progress consistently with the trends formulated by previous research are of concern. In the data presented throughout this thesis, a strong negative correlation is seen to exist between children’s use of English language in Primary 4 to 6 and both the number of responses and the quality of their explanations. A plausible factor that contributes to this phenomenon is that Brunei children of 9 to 11 years of age have limited English vocabulary to express their thinking in English.

Lack of language discipline

The poor explanations of science in English observed in this study may have been exacerbated by the children being conditioned in the classroom to communicate in whatever language they were most comfortable. The discourse of the upper primary classrooms observed included the use of Malay alongside English. This culture of intermingled language use is a potential cause of problems when pupils are learning science. As explained earlier in Chapter 2, p. 21, the process of communicating in English among the locals is sometimes mediated by translating English words to Malay and vice versa. This culture is crucial in the science classroom as, in the process of translation, meanings are often exaggerated, diminished and confused.

It would appear from the results of this study that due to the culture of dual language use in the classroom children provided explanations in both languages even when they were asked to communicate their ideas in one particular language. However, in this study, for the upper primary levels, children’s responses were only accepted and analysed when they provided explanations in English. Responses in Malay, whether they were correct or not, were regarded as ‘no response’. Coupled with the fact that they had to communicate science ideas that they themselves were not sure of, the children’s reticence to respond was potentially exacerbated because they were required to produce explanations in English sentences in which they were not well educated, or experienced in using. So while the findings are faithfully reported from
the study, the situation of only speaking in English is not the norm in classrooms in Primary 4 in Brunei.

Evidence of conceptual change from two different perspectives

A primary tenet of the theoretical framework of this research was that to understand conceptual development in a holistic way, it is necessary to acknowledge evidence of conceptual change from multiple perspectives. As data in this study were explored and interrogated from ontological and epistemological perspectives, it was realised that indications of conceptual change from these different perspectives were confirmatory in some ways and inconsistent in other ways. The findings presented in this study indicate that evidence of conceptual change from Chi’s ontological perspective is not necessarily supported by evidence of conceptual change from an epistemological perspective of Hewson and Hewson (1992) (see Chapter 7, section 7.7.2, p. 210).

The implication of this finding is that even though a single perspective of conceptual change can offer a clear and useful representation of the patterns of children’s understanding of science concepts, this kind of evidence should be considered limited for the purpose of analysis and interpretation. Rather, it would be educationally and ethically sound to pursue data that will provide an overview of children’s understanding from multiple perspectives. The multi-dimensional model proposed by Tyson et al. (1997), and utilised by Venville and Treagust (1998) and Harrison and Treagust (2001) that incorporates several perspectives of conceptual change was particularly illuminating for interpreting student understanding of the scientific concepts examined in this context.

9.3 Limitations to the Study

There are three methodological limitations to this study. First, the sample was from two primary schools, one for each science concept, and this may have influenced the reliability of the results. Second, due to delays in the analysis of the first phase of interviews, the second phase of interviews was conducted 14 months later. During this period, some pupil’s conceptions of evaporation and condensation changed. The second phase of interviews did, however, provide a rich source of in-depth
information about the pupil’s understanding and communication about the concepts in both Malay and English. Third, this study involved only one period for data collection. The patterns of children’s conceptual development would be better described if data were collected from the same cohort at several points in time, that is, a longitudinal study (Cohen et al., 2000). The longitudinal research design, however, posed demands beyond the scope of this study. Due to the time constraints of doctoral research, the cross-sectional research design was the best alternative available.

9.4 Implications

This study has explored a range of possible dilemmas and mediating constraints that affect Brunei children by analysing closely their patterns of conceptual development. In this respect, the rhetoric of ‘a system that solves problems’ can be juxtaposed to the reality of ‘a system that creates potential for new problems’. What the Brunei system of education faces here is a vicious circle: on the one hand, English is critical as the language of education and employment; on the other hand, English is an obstacle to the successful learning of science in the early years of schooling. The following sections will examine the practical implications for this system in a broader sense.

Assessment

It is common practice for teachers to teach to examinations. With constant drilling and memorization of facts for the sake of passing examinations, children will not only be promoted to the next level, they will often achieve excellent results. However, this style of assessment does not necessarily reflect the children’s actual conceptual development or true understanding of science. When school examinations are poorly and arbitrarily planned and pupils are judged to have good understanding in science based on those examinations, the consequences for future achievement may be dire. Rote learning that enables children to pass local tests and examinations with poor understandings of science concepts will result in those children suffering during the final public examinations in Primary 6 which tend to be better planned and are set external to the school. If the children have a good
conceptual understanding, no matter who sets the exam questions, they are more likely to be able to answer correctly. The final public examination in Primary 6 is in English and the extent of damage is likely to be compounded for those pupils who have limited second language proficiency. The results of this study are very important for Brunei primary science teachers if assessment is to continue to be based solely on pupils’ understanding of science concepts in English.

Classroom teaching

A matter of concern is that this poor conceptual understanding is not addressed through classroom teaching and there is, therefore, a strong possibility that alternative conceptions will be perpetuated from one level to the next. There is evidence presented in Chapter 6 (section 6.1.2, p. 140 – 142) and Chapter 8 (section 8.1.2, p. 227 – 228) that alternative conceptions evident in the lower primary levels were also present in the upper primary children’s interviews. Children’s poor conceptual understandings of science concepts are not attended to for two potential reasons. The first reason is that due to a lack of English proficiency among children, teachers are not able to diagnose alternative conceptions. The second reason is that due to the strong tradition of didactic, teacher-centred approaches in Brunei primary schools, children are not given enough opportunities to express their ideas. Either way, this leaves little possibility that alternative conceptions will be diagnosed or conceptual change encouraged. Most importantly, both these situations create considerable difficulties that classroom teachers find very difficult to address.

Teachers and communication

With limited English language proficiency, children in Brunei will undoubtedly have difficulty in trying to understand their teacher’s explanations in science. Malay words are used by teachers in unpacking meanings for concepts in some contexts. In some of the upper primary classrooms observed, Malay was used and accepted alongside English for communication (see Chapter 4, section 4.6.4.3, p. 93 - 97). While it is acknowledged that this practice may be beneficial in some circumstances for English learners, teachers, especially those without appropriate training, often portrayed a sense of confidence and comfort when teaching in Malay and,
conversely, a lack of confidence and discomfort when teaching in English. It needs to be recognised that these teachers are teaching in their second, or sometimes third, language and may not have adequate English language proficiency or vocabulary themselves to help pupils learn science in English.

Classroom culture

Children in Brunei are given little guidance about how to respond to open ended questions. In fact, in Brunei culture it is expected that young pupils provide ‘yes’ or ‘no’ responses to their teacher’s questions without elaboration. The cartoon illustrated in Chapter 3, Figure 3.1, p. 59, shows such typical classroom culture where answering teacher’s questions is not an imperative. Single word responses generally do not promote children’s thinking and this practice locks them into patterns of guessing the correct response. If children are conditioned to respond only to closed questions, this will impede a culture of thinking, of discussion, debate and contemplation that is necessary for learning science (Venville, Adey, Larkin & Robertson, 2003). Moreover, there will be a tendency that as the children grow up and some become teachers, similar patterns of questioning will persist and the cycle will continue.

Learning other subjects

If understanding in science is compromised because of children’s failure to grasp fluency in English then children’s understanding in other subjects, such as mathematics and geography, also may be in jeopardy. One pupil explained during his interview (see the excerpt from Udin’s English interview, p. 205 – 206), that he learnt the idea that there is water in the air by learning the concept of the water cycle in a geography lesson. This provides evidence that the learning of concepts in the context of one subject, like geography, can help the understanding of concepts in the context of another subject, like science. Consequently, the inability to perceive and explain valid conceptions about the water cycle in science lessons because of limited English proficiency will undoubtedly influence the understanding of the water cycle and other related concepts in geography lessons and vice versa.
9.5 Recommendations

The findings of this study only reflect a snapshot of the educational context in Brunei. It would be irresponsible to assume that the problems identified in this study will regress in due course without some effort taken to ensure the success of Brunei's bilingual education system. Most importantly, it must be recognized that there are many factors that have a part to play in the successful implementation of the system. These include the school curriculum, the English syllabus, teacher support, teacher training, teacher's qualifications, tests and examinations, classroom practice, parents' involvement, children's awareness and the language of school.

School curriculum

English language should be given more emphasis in the lower primary levels so that language proficiency will be well-established when children start learning science in English in Primary 4. Providing greater opportunities to learn English in school, however, can only be done at the expense of losing a number of hours learning Bahasa Melayu or Malay language. It is, therefore, extremely complicated and political to determine the proportions of time to be allocated to each language and the most appropriate timing of changes. One suggestion is to make the syllabus less rigid and less structured so that teachers who are close to the children and understand their language needs, can make appropriate decisions. Perhaps it is time to consider the teaching and learning of all subjects in a more integrated manner. The integrated approach is seen to promote better opportunities for language use (Rakow & Vasquez, 1998).

The English syllabus

While it is unrealistic to expect wholesale changes to the English syllabus in the primary school, it is not unreasonable to expect continuous improvement informed by recent research findings (Calhoun et al., 2001; McGillick, 1993; Wan, 1996). One improvement to the English syllabus that can be recommended as a result of this study is that the teaching of English language should be seen as the development of all four skills, including writing, reading, speaking and listening. Not only is language a crucial means of determining evidence of and enhancing conceptual
change, competence in oral language is the key for children’s success in learning a language. In the current primary school curriculum, the oral language skill is not emphasized. Oral language competence in English is only seen as important when students are in Form 3 (14 years of age) when they have to pass an oral examination before being promoted to Form 4. An effective English syllabus should include a high priority on oral practices and this also is likely to improve students’ learning of science in English. It would be of great benefit to the Brunei bilingual education system if greater attention was given to the teaching of oral English language as early as in the lower primary school.

Teacher support

Teachers need to be informed about children’s patterns of understanding in science that have been illustrated in this study. One way forward is to encourage in-service courses for school teaching staff, school administrators and most importantly, curriculum planners to include research-based information in their planning and policies. If this recommendation is implemented, a thorough evaluation of classroom management, the curriculum and the quality of classroom interaction should be put on the agenda for improving the teaching of science within Brunei’s bilingual education system. For example, a teaching resources centre could be established to provide interesting and relevant teacher support materials such as class handouts, posters and worksheets (Jones, 2000c).

Teacher training

The supply of properly trained teachers who are proficient in the language medium through which they will teach should be ensured (Jones, 2000c). Teacher training institutions, in particular, should prepare student teachers for education in a bilingual environment. While student teachers in Brunei are seen to be able to write in English well, many of them are not confident in speaking the language. One way forward is to encourage these student teachers to communicate their ideas orally in English more frequently. Currently, however, the large number of student teachers means that mass lectures are the main mode of instruction in the teacher training institution. As a result, very little modelling of good teaching practices are observed. With no
small group tutorials in primary education programs, there are few opportunities for student teachers to communicate in English with their tutors or lecturers. If this scenario continues, there will always be a significant proportion of teachers who will fall short of being good role models for their pupils, especially in promoting the oral English language skills.

Tests and examinations

It would be an enormous challenge for the Brunei education system to move slowly away from recall style testing to examinations that reflect not only conceptual understanding in science but also the needs of language acquisition, especially at the primary levels. Yet, an analysis of the results in this study (see Chapter 6, section 6.4, p. 171 – 172) indicates that the present system of tests and examinations needs to include some elements of promoting language use. One potential step that could be taken towards an improved system is to include more open-ended questions in tests and examinations. Questions should be designed in such a way that children will not simply memorize facts and unconnected titbits of information about particular topics. The new system of testing also would encourage teachers to give more appropriate attention to provoking children to explain their ideas in the classrooms. Change such as this would require a high level of commitment from higher educational authorities, for example, the school administrators and school inspectors.

Classroom practice

The opportunity for language use in conjunction with science learning in classrooms should be promoted in Brunei. A point has to be quickly reached that teachers treat ‘talk’ in classrooms as a resource for improving better communication in English as well as providing learning opportunities in science. Teachers should create a non-threatening environment in which children can talk about concepts and ideas in this language in the classroom without feeling embarrassed. This can be done by organising small group activities that require pupils to co-operate, articulate their ideas and discuss answers to questions and problems. In this respect, children must be continuously motivated and encouraged to take responsibility for classroom
discussion. Moreover, the children need to receive positive feedback from their teachers and their peers.

Children's awareness

Despite all schools following the same curriculum, children in some schools are seen to achieve better results and career opportunities than others. This suggests that there are factors other than the curriculum determining success. Having qualified teachers is obviously a factor. Another less obvious factor is the children's awareness on the importance of English. Impressions from the classroom observed in this study (see Chapter 4, section 4.6.4.3, p. 93 – 94) suggest that some children were not motivated to articulate their ideas in English during lessons. This attitude of complacency is likely to contribute to the children not acquiring sufficient English words for general communication and for learning science. As a result, when asked for the meaning of the word ‘living’, some children simply named a place instead of discussing living organisms and the criteria for life (see Chapter 8, section 8.1.1.3, p. 217 – 218). This poor motivation to learn and use English may stem from children lacking awareness of the importance of English. It is possible that to some, the message that English language is the key for a better career opportunity is understood only at the point-in-time when they are applying for jobs or seeking places at the tertiary level. A practical, potential solution to this situation is to convey to all children as early as possible the necessity of English language proficiency and a broad vocabulary. Exposure to English and positive attitudes towards communicating in English could be encouraged through media, for example, local educational television programs, through teacher education programs and generally within the Brunei school system. While an individual may appreciate the importance of Malay, the same individual can also understand the need and benefits of acquiring English.

Language of school

Given the nature of the system, Malay and English languages are both widely accepted by the Brunei pupils as the languages of school. However, as all the pupils and most of the staff are Malay, it is possible that Malay is spontaneously used more
often than English during assemblies, extra curricula activities and informal gatherings or functions. To some extent, the use of Malay as the preferred language of school, could perpetuate the perception to the children that communication in Malay is more important and a priority. This perception should be addressed so that both Malay and English are seen to have equal status when used by staff. In particular, the school’s administrative staff should promote English as an equally important part of the language of school. It may be prudent for the Brunei Ministry to expend some resources to investigate how bilingual approaches in other countries are implemented.

Looking forward to potential solutions

There are several potential solutions to the problems highlighted in this study that could be achieved by adjusting the level at which the English language is introduced as the medium of instruction. However, each of these potential solutions seems to create other problems. For example, science could be taught in Malay throughout the primary years, but this strategy would not solve the problem of pupils having to sit university entrance examinations in English. Another potential solution is to gradually introduce the English language into a few subjects each year so that by Primary 6, English is the language of instruction for all subjects. But which subjects would come first, and when would it be ideal for science to change to English medium instruction? Moreover, a system of gradual implementation is likely to perpetuate many of the problems discussed in this final chapter that relate to the dual use and acceptance of both languages for classroom discourse.

Rather than change the age for the introduction of the English language in schools in Brunei, another, less revolutionary, approach is to improve the current system. Each of the previous paragraphs in this section on recommendations has included suggestions that a shift to a focus on language, particularly the oral component of the English language, will improve the learning of science in this bilingual context. The previous sections suggested changes to the school curriculum and English syllabus to improve lower primary pupils’ understanding of English and their spoken English. Further suggestions included better training for teachers, resources and in-service courses so that teachers can better integrate language with science
language with science teaching. Moreover, the modification of tests and examinations to incorporate a language component that requires children to explain their understandings and a classroom and school culture that motivates and encourages pupils to communicate in English were all aspects of the recommendations. If we consider these recommendations holistically, the focus on language needs to permeate all aspects of schooling. Not only is this strategy likely to improve Brunei pupils' spoken English, such a strategy is likely to improve Brunei pupils' learning of science.

9.6 Future Research

This study found that there is a gap between the point when children acknowledge that plants are living and the development of the knowledge that plants have the essential characteristics of living things. It seems that the children in this study had a different way of believing that plants are living that is not based on credible scientific criteria (see Chapter 8, section 8.5, p. 255). Future research should involve further probing of children's thoughts and understandings associated with this anomaly.

The main finding of this study was that Brunei primary children were found to have low levels of English proficiency that prevented students from achieving in science when the English language is used in Primary 4. It would be fruitful to conduct parallel research in other countries that also have a bilingual system of education to ascertain whether the conclusions of this study are transferable to those contexts. In this way, the results of this study can be validated and a better understanding of bilingual education systems and the teaching and learning of science will be generated. Some research also needs to be instigated to determine the level of motivation for Brunei children to learn English. If the motivation level is low, then solutions to increase motivation should become the next priority. Equally important is teachers' attitude towards the use of English as the medium of instruction. Their attitudes and motivational level should also be determined to assist the development of positive classroom interaction between pupils and teachers.

The most interesting and potentially beneficial research that could be conducted in the future is to evaluate the implementation of the recommendations of this research.
For example, future research could investigate the impact that a focus on language in the science classroom has on pupils' understandings of and achievement in science.

9.7 Finale

Given the implications of this study, there is no reason not to be optimistic about the future of the bilingual system of education in Brunei. However, improvement requires courage, effort and commitment at all levels of the education community in order to transform the dream of excellent education through a bilingual system into a reality.
REFERENCES


education in Australasia and the South Pacific. Clevedon: Multilingual Matters Ltd.


Place, J. D. (1997). 'Boys will be boys' - Boys and under-achievement in MFL. Language Learning Journal, 16(September), 3-10.


APPENDIX A
THE COMPLETE INTERVIEW PROTOCOL FOR EVAPORATION AND
CONDENSATION FOR THE LOWER PRIMARY LEVEL (TRANSLATED
INTO ENGLISH)

WATER

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire only asks you to describe your overall knowledge on
   water and related concepts. This is NOT a test. No marks will be given for
   your answers. Nobody will be allowed to see your work except the
   researcher. So, please answer your questions as best as you can.

2. **About the Questionnaire**
   There are three sections in this questionnaire, Section A, Section B and
   Section C. The direction on how to answer each section is indicated in every
   section.

3. **About yourself**
   Please provide information in the box below. Remember, your answers to
   this questionnaire will be treated as confidential.

<table>
<thead>
<tr>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary:</td>
</tr>
<tr>
<td>Age:</td>
</tr>
<tr>
<td>Sex: male / female (please circle one)</td>
</tr>
</tbody>
</table>

THANK YOU
SECTION A

Choose the correct answers and put a tick (✓) in the boxes provided. Where necessary answer the following questions.

1. Look at the pictures below.

Picture A (clouds)

Picture B (ice)

Which picture shows water in its solid form?

A. Picture A

B. Picture B
2. Refer the picture below.

a. One hour after the rain, what would happen to the puddle of water?
   A. It would stay the same
   B. It would become a bigger and bigger puddle
   C. It would soon become smaller

b. Why?

   ___________________________________________________________
   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________

   ___________________________________________________________
3. Samples of washed clothes are immersed in water and hung outside under the hot sun.

   a. What would happen to the clothes after a few hours?
      A. The clothes would remain wet
      B. The clothes would become dry
      C. The clothes would become very wet

   b. Why?

   c. Where would the water go?
      A. The water would go to the earth
      B. The water would go to the air
      C. The water would hide in the clothes
4. There are two dishes filled with 10ml of water. Dish A is placed in the sunlight and Dish B is in the shade.

DISH A

DISH B

a. After 4 hours, what would happen to water in dish A?

A. The water would remain the same

B. The water would become less

C. The water would become more
b. After 4 hours, what would happen to water in dish B?
   A. The water would remain the same
   B. The water would become less
   C. The water would become more

   [ ]

   c. In which dish would the water 'disappear' faster?
   A. Dish A
   B. Dish B

   [ ]

   d. Why would you think so?


5. The picture below shows a boiling kettle.

   ![Boiling kettle image]

   a. When a kettle boils, what would you see coming out of it?
   A. steam
   B. water
   C. ice

   [ ]
b. Where would you think it might go?
   A. Back to the kettle
   B. To the air
   C. Just disappear

   

c. Why would you think 'the thing' comes out of the kettle?
   A. Because the water in the kettle is hot
   B. Because the water in the kettle is full
   C. Because the water in the kettle is cold

6. One can of coca cola is put in a refrigerator. After 2 hours, it is set on a table.

![Image of a can of coca cola]

a. What would you notice about the outside of the can?
   A. It would be wet
   B. It would be dry
   C. It would be hot
b. Why would the outside of the can be wet?

A. Because of the water in the air
B. Because of the water inside the can
C. Because of the water in the refrigerator

A. No
B. Yes
C. I don't know

SECTION C

Below is a picture of water cycle from Primary 3 textbooks.

Describe the picture.
SECTION A

For each sentence, please circle only one number corresponding to your answer. For instance:

- If you think that you ‘Strongly Agree’ sea water is salty, circle 5.

<table>
<thead>
<tr>
<th>Water</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. We can live without water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. People will become ill if they go without water for a week.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Water is everywhere.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. There is water in the air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. There is water in the clouds.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Ice is water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Without rain, we will not have water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. We drink water which comes from the rain.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaporation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. During raining, roads will become wet.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. When the rain stops and we let the roads in the sun for 30 minutes, the roads will become warm.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
11. After few hours under the sun, the roads will be dry.  
   5  4  3  2  1
12. The sun makes the roads warm.  
   5  4  3  2  1
13. Washing dries best on a sunny day.  
   5  4  3  2  1
14. When wet clothes are hung under the sun for a few hours, the clothes become dry.  
   5  4  3  2  1
15. The water from wet clothes disappears to the air.  
   5  4  3  2  1

<table>
<thead>
<tr>
<th>Condensation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don't Know</th>
</tr>
</thead>
</table>
| 16. Rain comes from clouds.  | 5  4  3  2  1
| 17. We can see clouds.  | 5  4  3  2  1
| 18. All clouds contain water vapour. | 5  4  3  2  1
| 19. Water returns to the earth as rain.  | 5  4  3  2  1
| 20. A cup is filled with ice. After 30 minutes, the cup will feel cold and wet.  | 5  4  3  2  1
| 21. The water on the outside of the cup comes from the air.  | 5  4  3  2  1
| 22. There is water vapour in the air.  | 5  4  3  2  1
| 23. We cannot see water vapour in the air.  | 5  4  3  2  1

299
APPENDIX B

THE COMPLETE INTERVIEW PROTOCOL FOR EVAPORATION AND
CONDENSATION FOR THE UPPER PRIMARY LEVEL

WATER

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire only asks you to describe your overall knowledge on water and related concepts. This is NOT a test. No marks will be given for your answers. Nobody will be allowed to see your work except the researcher. So, please answer your questions as best as you can.

2. **About the Questionnaire**
   There are three sections in this questionnaire, Section A, Section B and Section C. The direction on how to answer each section is indicated in every section.

3. **About yourself**
   Please provide information in the box below. Remember, your answers to this questionnaire will be treated as confidential.

<table>
<thead>
<tr>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary:</td>
</tr>
<tr>
<td>Age:</td>
</tr>
<tr>
<td>Sex: male / female (please circle one)</td>
</tr>
</tbody>
</table>

THANK YOU
SECTION A

Refer to the pictures given and answer the questions in your own words.

1. Which picture shows water in its solid form?

Picture A (clouds)

Picture B (ice)

Picture A OR Picture B? ________________
2. If you try to put solid and liquid forms of water into a container, which will fit the container’s shape?

[SOLID OR LIQUID?

3. Refer to the picture below.

[a. One hour after the rain, what would happen to the puddle of water?]
b. Why?

---

4. Clothes are washed and hung outside under the hot sun.

---

a. What would happen to the clothes after a few hours?

---

b. Why?

---

c. Where would the water go?

---
5. There are two dishes filled with 10ml of water. Dish A is placed in the sunlight and Dish B is in the shade.

DISH A

DISH B

a. After 4 hours, what would happen to water in dish A?
b. After 4 hours, what would happen to water in dish B?


c. In which dish would the water ‘disappear’ faster?


d. Why would you think so?


6. The picture below shows a boiling kettle.

![Boiling Kettle Image]

a. When a kettle boils, what would you see coming out of it?


b. Why would you think it comes out of the kettle?
c. Where would you think it might go?

7. One can of coca cola is put in a refrigerator. After 2 hours, it is set on a table.

a. What would you notice about the outside of the can?

b. Why would the outside of the can be wet?

c. Do you think it is necessary to fill the can with coca cola to make the outside of the can moist?
SECTION B

Below is a picture of water cycle from Primary 3 textbooks.

Describe the picture in your own words.
### SECTION C

For each sentence, please circle only one number corresponding to your answer. For instance:

- If you think that you 'Strongly Agree' sea water is salty, circle 5.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sea water is salty.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. We can live without water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. Water is everywhere.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. There is water in the air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. River water comes from the rain.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. Without rain, we will not have water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Ice is not water.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Water cannot be in solid form.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. All water is used over and over again.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaporation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Water in an open dish will become less and less after one hour.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. Puddles of water in the shade will disappear faster than puddles in the sun.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11. Washing dries best on a sunny day.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
12. Water from wet clothes hung outside disappears in the air. 5 4 3 2 1
13. When water boils, it lets off steam to the air. 5 4 3 2 1
14. Some river water also disappears to the air. 5 4 3 2 1
15. The sun warms up river water and this water changes into steam. 5 4 3 2 1
16. A puddle of water on the road which begins to ‘disappear’ is evaporating. 5 4 3 2 1

<table>
<thead>
<tr>
<th>Condensation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>17. Rain comes from clouds.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Water vapour creates clouds.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Water returns to the earth as rain.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. All clouds contain water vapour.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. A cup is filled with ice. After 30 minutes, the outside the cup will feel cold and wet.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. The water on the outside of the cup comes from the air.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. The water on the outside of the cup comes from the ice in the cup.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. There is water vapour in the air.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. When warm air containing water vapour hits something cool, the water vapour turns into a liquid.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Condensation is the changing of water vapour into a liquid.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

THE COMPLETE INTERVIEW PROTOCOL FOR EVAPORATION AND CONDENSATION FOR THE LOWER PRIMARY LEVEL

PANDUAN

1. **Tujuan soal selidik**

2. **Mengenai soal selidik**
   Soal selidik ini terbahagi kepada tiga bahagian, Bahagian A, B dan C. Panduan bagi menjawap soalan-soalan tersebut ada dinyatakan disetiap bahagian-bahagian.

3. **Mengenai diri kamu**
   Sila berikan maklumat mengenai diri kamu di dalam kotak yang disediakan di bawah ini. Semua jawapan yang diberi akan dirahsiaikan.

<table>
<thead>
<tr>
<th>Nama:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Darjah:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Umur:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Jantina: lelaki / perempuan (bulatkan satu)</td>
</tr>
</tbody>
</table>

**TERIMA KASIH**
BAHAGIAN A

Pilih jawapan yang kamu fikirkan betul dan isikan ke dalam kotak yang disediakan. Bagi beberapa buah soalan, jawap soalan-soalan tersebut dengan ayat serta kefahaman kamu sendiri.

1. Lihat gambar-gambar di bawah ini.

Gambar A (awan)

Gambar B (ais)

Gambar yang mana satukah yang menunjukkan bentuk pejal air?

A. Gambar A
   
B. Gambar B
2. Sila rujuk gambar di bawah ini.

![](image)

a. Apakah yang akan terjadi pada takungan air satu jam selepas hujan turun?
   
   A. Air masih sama banyak
   
   B. Air semakin banyak

   C. Air semakin sedikit

b. Kenapa ianya terjadi demikian?

   __________________________________________

   __________________________________________

c. Kemanakan air dalam takungan tadi menghilang?

   A. Air telah menyerap ke dalam tanah

   B. Air telah menghilang ke udara

   C. Air telah hilang
3. Gambar di bawah menunjukkan kain yang telah direndam, dicuci dan dijemur di bawah matahari.

a. Apakah yang akan terjadi pada pakaian-pakaian tadi selepas beberapa jam?
   A. Pakaian-pakaian itu masih basah.
   B. Pakaian-pakaian itu telah kering
   D. Pakaian-pakaian itu telah menjadi semakin basah

b. Kenapa kamu fikir ia akan terjadi sedemikian?

____________________________

____________________________

____________________________

c. Kemanakan air dalam pakaian itu akan pergi dan menghilang?
   A. Air akan menyerap ke dalam tanah
   B. Air akan menghilang ke udara
   C. Air akan bersembunyi di sebalik pakaian-pakaian tadi
4. Dua buah bekas telah diisi dengan air sebanyak 10ml ke dalam setiap satu. Bekas A telah diletakkan di bawah sinaran matahari dan bekas B diletakkan dibawah sebuah pokok.

![GAMBAR A](image)

![GAMBAR B](image)

a. Apakah yang akan terjadi pada air didalam bekas A selepas 4 jam?

A. Air masih sama banyak

B. Air akan menjadi sedikit

C. Air akan bertambah banyak
b. Apakah yang akan terjadi pada air didalam bekas B selepas 4 jam?
   A. Air masih sama banyak
   B. Air akan menjadi sedikit
   C. Air akan bertambah banyak

c. Air dalam bekas manakah yang akan 'menghilang' dulu?
   A. Bekas A
   B. Bekas B

d. Kenapa kamu fikir air dalam bekas ini akan 'menghilang' cepat?

5. Gambar di bawah ini menunjukkan cerek yang mengandungi air yang sedang mendidih.

   ![Gambar cerek yang sedang mendidih]

   a. Apakah yang dapat kamu perhatikan bila air di dalam cerek mendidih?
      A. Wap akan keluar dari cerek
      B. Air akan keluar dari cerek
      C. Ais akan keluar dari cerek
b. Kemanakah kamu fikir ia akan 'pergi'?
   A. Balik semula ke dalam cerek
   B. 'Pergi' ke udara
   C. Terus menghilang

c. Kenapakah kamu fikir ia akan keluar dari cerek tersebut?
   A. Kerana air di dalam cerek itu terlalu panas
   B. Kerana air di dalam cerek itu terlalu penuh
   C. Kerana air di dalam cerek itu sejuk


   ![Image of tin with condensation](image)

a. Perhatikan permukaan tin tersebut. Apakah yang mungkin kamu dpati?
   A. Permukaan tin akan menjadi basah dan berair
   B. Permukaan tin akan kering
   C. Permukaan tin akan menjadi panas
b. Kenapakah permukaan tin tadi menjadi basah dan berair?
   A. Kerana air yang di dalam udara
   B. Kerana air yang di dalam tin coca cola
   C. Kerana air yang di dalam peti ais

c. Adakah kamu fikirkan perlu untuk mengisi air ke dalam tin coca cola tadi supaya permukaannya akan basah dan berair?
   A. Perlu
   B. Tidak perlu
   C. Tidak tahu

BAHAGIAN B

Di bawah ini menunjukkan sebuah gambar sumber air yang diambil dari buku Pelajaran Am Darjah III.

Sila huraiakan gambar tersebut.
BAHAGIAN C

Bulatkan satu nombor yang sangat sesuai dengan jawapan kamu bagi setiap satu ayat di bawah ini. Misalannya:

- Jika kamu fikir ‘Sangat Bersetuju’ air laut adalah masin, bulatkan 5.

<table>
<thead>
<tr>
<th>Air</th>
<th>Sangat Bersetuju</th>
<th>Bersetuju</th>
<th>Tidak Bersetuju</th>
<th>Sangat Tidak</th>
<th>Tidak Tabu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kita tidak boleh hidup tanpa air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Manusia akan sakit jika mereka jika tidak ada air selama seminggu.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Air ada di mana-mana.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Air ada di udara.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Air ada di awan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Ketulan ais adalah air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Tanpa hujan, kita tidak akan ada air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Kita minum air yang datang dari hujan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Penyejatan | Sangat Bersetuju | Bersetuju | Tidak Bersetuju | Sangat Tidak | Tidak Tabu |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td>Semasa hujan, jalanraya akan basah.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Bila hujan berhenti, dan matahari kembali memancar selama 30 minit, jalanraya akan menjadi panas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>Selepas beberapa jam, jalanraya tadi akan kering.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

318
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12.</td>
<td>Jalanraya tadi telah kering kerana pancaran matahari.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>Mencuci pakaian sangat sesuai dilakukan disiang hari.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14.</td>
<td>Jika menjemur pakaian yang basah di bawah sinaran matahari selama beberapa jam, pakaian tadi akan kering.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15.</td>
<td>Air yang didalam pakaian tadi akan menghilang ke udara.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pemeluapan</th>
<th>Sangat Bersatu</th>
<th>Bersatu</th>
<th>Tidak Bersatu</th>
<th>Sangat Tidak Bersatu</th>
<th>Tidak Tahu</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.</td>
<td>Hujan turun berpunca dari awan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Kita boleh melihat awan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18.</td>
<td>Awan mengandung wap.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19.</td>
<td>Air kembali ke bumi sebagai hujan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>Sebiji gelas telah diisi dengan ais. Setelah 30 minit, gelas tadi akan menjadi sejuk dan basah.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>21.</td>
<td>Air yang di permukaan gelas tadi berasal dari air yang berada di udara.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>22.</td>
<td>Udara mengandungi wap ataupun gas yang terjadi daripada air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>23.</td>
<td>Kita tidak boleh melihat wap ataupun gas yang terjadi daripada air.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

319
<table>
<thead>
<tr>
<th>Primary Levels</th>
<th>Concepts</th>
<th>Introduction</th>
<th>Primary 1</th>
<th>Primary 2</th>
<th>Primary 3</th>
<th>Primary 4</th>
<th>Primary 5</th>
<th>Primary 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A. About me</td>
<td>My district</td>
<td>The environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- My self</td>
<td>- Name and location</td>
<td>- Towns in Brunei</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- My house</td>
<td>- High and low lands</td>
<td>- Bandar Seri Begawan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- My village</td>
<td>- Rivers</td>
<td>- Buildings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Basic needs</td>
<td>- Vehicles</td>
<td>- Map</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B. Food</td>
<td>- Things</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C. Earth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D. Sun</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E. Moon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>F. Stars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cleanliness of the body</td>
<td>Infectious diseases</td>
<td>Environmental and human health</td>
<td>Diseases spread by animals</td>
<td>Airborne diseases</td>
<td>A. Waste disposal</td>
</tr>
<tr>
<td>Living things</td>
<td>A. Plants that can be eaten and cannot be eaten</td>
<td>Living and non-living things</td>
<td>A. Non-living things (things that float and sink)</td>
<td>A. Simple classification of plants</td>
<td>A. Flowering plants</td>
<td>- Identifying and naming freshwater animals and plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------</td>
<td>-------------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Plants live</td>
<td>- Animals that lay eggs</td>
<td>- Animals that</td>
<td>a. Groups</td>
<td>- Shoot and root system</td>
<td>- Project work</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td></td>
<td>- herbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Types of rubbish or refuse
- Common ways of disposing rubbish

B. Our body and the waste - simple explanation

C. Harmful substances (food) for our health

D. Uses of medicines

E. Misuse or abuse of drugs

F. Effects of abuse of drugs
<p>| C. Animals live on land and in water | give birth to young ones - Animals that are hairy, scaly, etc - Animals with two, four, six or eight legs - Animals without legs - Animals and their habitats - Animals and their foods - Parts of a plant - Soft and hard plants - Leaves - Local and imported fruits - Flowers and their colours - Seeds | B. Parts of a fish, bird and cat - Shrubs - Trees b. Classifications - Flowering - Non-flowering - B. Classification of animals a. Animals with backbones - Mammals - Birds - Reptiles - Amphibians - Fish c. Animals without backbones | C. Animals and their ways of movement | B. Animals with backbones and their ways of breeding | their uses - Fruits and seeds - B. Animals with backbones and their ways of breeding | on freshwater living things (pond-life or aquarium) - Food chain - Simple survey on the consumption of any freshwater animals |
| Teeth | Teeth | Teeth | Teeth | Teeth | Teeth | Teeth |
| Foods | A. Foods and drinks | - People and their food | - Different classes - Importance of food | - Uses - Structure - Causes of tooth decay - Proper care | - Different classes - Importance of food | - Uses - Structure - Causes of tooth decay - Proper care | - Uses - Structure - Causes of tooth decay - Proper care |
| B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and | B. Places to keep the foods and |</p>
<table>
<thead>
<tr>
<th>drinks</th>
<th>Air</th>
<th>Heat</th>
<th>Sound</th>
</tr>
</thead>
</table>
|        | A. Weather  
- warm  
- cold  
- rain  
- wind  
C. Wind direction  
D. Sources of water | - Air is around us  
- Air occupies space  
- Air has weight  
- Air has pressure  
- Wind is the movement of air  
- The importance of air  
- Our breathing system | - Sources of heat  
- Uses of heat  
- Hot and cold substances  
- Temperature of human body, boiling water, ice, room temperature and tap water  
- Simple activities to demonstrate how the heat flows in air, liquid and solid |
|        | Identifying the sounds of human | - Sources of sound |
| Light | | beings, animals, machines and musical instruments | - Pleasant and unpleasant, soft and loud sound  
- Sound travels through air, liquid and solid  
- Structure of human ear  
- Care of the ear |

| Magnet and Magnetism | | | - Sources of light and their uses  
- Concepts of translucent, transparent and opaque materials  
- Shadow  
- Light travels in a straight line  
- Light can be reflected  
- Light has many colours  
- External structure of the eye  
- Care of the eye  
- First aid for eye injury  
- Introducing magnets (types and
<table>
<thead>
<tr>
<th>Electricity</th>
<th>shapes, poles, compass bearing</th>
<th>Magnetic and non-magnetic substances</th>
<th>Attraction and repulsion</th>
<th>Making artificial magnets</th>
<th>Magnet and compass</th>
<th>Uses of magnets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Making simple electric circuit (closed, open, series and parallel)</td>
<td>Simple switch</td>
<td>Conductors of electricity</td>
<td>Simple experiment to find out whether electricity can flow through tap water, salt water and lemon water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple machines</td>
<td>Sources of electricity</td>
<td>Safety and precautions with electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------</td>
<td>------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>What is a machine? (what machine can do and examples of simple machines)</td>
<td>Types of simple machines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What is energy? (common forms and sources of energy)</td>
<td>Uses of different forms of energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E
THE COMPLETE INTERVIEW PROTOCOL FOR LIVING AND NON-LIVING FOR THE UPPER PRIMARY LEVEL

INTERVIEW ON LIVING RESPONSE SHEET

Name: .............................................. Class: .............................
Age: ....................... yrs old School: .............................
Date: .............................

SECTION A

Answer the following questions.

1.  (a) Can you name some things that are living?

   Examples:

   (b) Why do you think that the above example(s) is/are living?

   Because:

   (c) Are there any other things that make you think that is living?

   Others:

   (d) Anything else that helps you to think it is living?

   ...other reasons:

2.  (a) Can you tell about some things that are not living?

   Examples:

   (b) Why do you think it is not living?

   Because:

   (c) Is there anything else that makes you think that is not living?

   ...other reasons:
3.  (a) Was a dead cat ever living?
   (b) Do you know some things that have never been living?
   (c) Do you think it is not living?
   (d) Why do you think that it is not living?

4.  Do you know what living means? What does it mean?

SECTION B

Refer to the pictures below and answer the following questions.

1.  

Picture of a fire

   a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

2.  

Picture of a table

   a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?
3. a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

4. a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

5. a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

6. a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?
7. Picture of a television
   a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

8. Picture of a cloud
   a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

9. Picture of a house
   a. What do you think this is?
   b. Do you think this is living or not-living?
   c. What makes you think it is living / not living?
   d. Is there anything else that makes you think that is living / not-living?

10. Picture of a bird
    a. What do you think this is?
    b. Do you think this is living or not-living?
    c. What makes you think it is living / not living?
    d. Is there anything else that makes you think that is living / not-living?
SECTION C

1. Here are some examples of animals.

(Cow  dog  pigeon  parrot  lizard  snake  frog  fish  person)

(a) In how many ways can you group the animals?
(b) Explain in your own words how you decided on the groupings.
(c) In what ways are these animals similar?
(d) In what ways are these animals different with each other?
(e) Do you think all the above animals are living?
(f) What can you say about the characteristics of the animals above?

2. Now study the pictures below.

(Pictures of animals and plants)

(a) Can you group the things in the picture above?
(b) Explain in your own words how you decided on the grouping?
(c) In what ways are these things similar?
(d) In what ways are these different?
(e) Do you think these are living or not-living?
(f) In what ways are these things different from (use child’s example of non-living)?
### SECTION D

For each sentence, please circle only one number corresponding to your answer.
For instance:

- **If you think that you 'Strongly Agree' tiger is an animal, circle 5.**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All things in this world fall into two main categories of living and non-living.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Living things are things that are alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>A human being is alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Cats, birds and fish are all alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Plants, trees and flowers are all alive.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Something that is 'alive' has life! It is not an object and it is not dead.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Things that are alive can die.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Things that are alive need food to give them energy.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Things that are alive grow.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Things that are alive can reproduce things or have babies like themselves.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Statement</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11</td>
<td>A newborn baby grows into an adult.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Seeds grow into new plants.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>If something is living it can move and grow. If it cannot move and grow, it is non-living.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>Smoke is moving but it is not living because it cannot grow and reproduce.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>Animals and plants breathe.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>Plants can protect themselves.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>Animals are different in the way they breathe.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>Animals produce young in different ways.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>Plants need water, sunlight and air to make food.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>Fins help fish to swim and balance their body.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>Fishes can breathe in the water because they have gills.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>Certain animal populations feed on other populations.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>A human being is an animal.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX F
THE COMPLETE INTERVIEW PROTOCOL FOR LIVING AND NON-LIVING FOR THE LOWER PRIMARY LEVEL

LEMBARAN JAWAPAN BAGI TEMUDUGA KONSEP ‘BENDA-BENDA YANG HIDUP’

Nama: ........................................ Darjah: .........................
Umur: .........................tahun Sekolah: ............................
Haribulan: ........................ ........................

BAHAGIAN A

Jawap soalan-soalan di bawah ini.

1. (a) Namakan sesuatu yang hidup.
   Contoh:
   (b) Kenapa kamu fikir contoh di atas itu hidup?
   Kerana:
   (c) Selain dari itu, mengapa kamu yakin ia hidup?
   Kerana:
   (d) Apalagi sifat bagi sesuatu yang hidup?
   ...sifat yang lain:

2. (a) Namakan sesuatu yang tidak hidup.
   Contoh:
   (b) Kenapa kamu fikir ianya tidak hidup?
   Kerana:
   (c) Selain dari itu, apakah yang membuat kamu yakin ianya tidak hidup?
   ...kerana:
3. (a) Adakah seekor kucing yang telah mati pernah hidup?  
(b) Namakan sesuatu yang tidak pernah hidup?  
(c) Adakah ia sesuatu yang tidak hidup?  
(d) Kenapa kamu fikir ianya sesuatu yang tidak hidup?

4. Adakah kamu tahu tentang makna hidup? Apa dia ‘hidup’?

**BAHAGIAN B**

*Sila rujuk gambar-gambar di bawah ini dan jawap solan-soalan berikut.*

1. **Gambar api**
   a. Apakah ini?  
   b. Adakah kamu fikir ianya hidup atau tidak?  
   c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?  
   d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

2. **Gambar sebuah meja**
   a. Apakah ini?  
   b. Adakah kamu fikir ianya hidup atau tidak?  
   c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?  
   d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?
3. 

Gambar sebuah kereta

a. Apakah ini?
b. Adakah kamu fikir ianya hidup atau tidak?
c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

4. 

Gambar seorang budak

a. Apakah ini?
b. Adakah kamu fikir ianya hidup atau tidak?
c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

5. 

Gambar sepalen pokok

a. Apakah ini?
b. Adakah kamu fikir ianya hidup atau tidak?
c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

6. 

Gambar seekor kucing

a. Apakah ini?
b. Adakah kamu fikir ianya hidup atau tidak?
c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?
7. a. Apakah ini?
   b. Adakah kamu fikir ianya hidup atau tidak?
   c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
   d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

8. a. Apakah ini?
   b. Adakah kamu fikir ianya hidup atau tidak?
   c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
   d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

9. a. Apakah ini?
   b. Adakah kamu fikir ianya hidup atau tidak?
   c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
   d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?

10. a. Apakah ini?
    b. Adakah kamu fikir ianya hidup atau tidak?
    c. Apa yang membuat kamu fikir ianya hidup/tidak hidup?
    d. Apakah ada sifat lain yang membuat kamu yakin ianya hidup atau tidak hidup?
BAHAGIAN C

1. Sila rujuk gambar binatang di bawah ini.

(lembu anjing burung kakak tua burung merpati cicak ular katak ikan orang)

(a) Dalam berapa kumpulankah kamu dapat mengumpul binatang-binatang di atas?
(b) Nyatakan bagaimana cara pengumpulan itu dibuat.
(c) Apakah ciri-ciri yang sama yang terdapat pada semua binatang-binatang tersebut?
(d) Apakah ciri-ciri yang berlainan yang ada pada binatang-binatang tersebut?
(e) Adakah kamu fikir semua binatang-binatang tersebut hidup?
(f) Huraikan tentang ciri-ciri sesuatu yang hidup?

2. Sila lihat gambar di bawah ini.

(Gambar binatang dan pokok)

(a) Bolehkah kamu mengumpulkan gambar-gambar di atas menjadi beberapa kumpulan?
(b) Terangkan bagaimana pengumpulan itu dibuat?
(c) Apakah ciri-ciri yang sama yang terdapat pada semua gambar?
(d) Apakah ciri-ciri yang membuat satu kumpulan berlainan dengan kumpulan yang lain?
(e) Adakah semua yang terdapat dalam gambar-gambar itu hidup?
(f) Bagaimanakah binatang serta pokok dalam gambar ini berlainan dari .......... (meja dll)?
**BAHAGIAN D**

Tandakan bulatan pada nombor yang kamu fikirkan sesuai. Contoh:

- **Jika kamu sangat bersetuju** yang singa adalah seekor binatang, bulatkan 5.

<table>
<thead>
<tr>
<th></th>
<th>Sangat setuju</th>
<th>Setuju</th>
<th>Tidak setuju</th>
<th>Sangat tidak setuju</th>
<th>Tidak tahu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Singa adalah seekor binatang.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. Benda hidup adalah benda yang hidup.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Manusia adalah hidup.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. Kucing, burung dan ikan semuanya hidup.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. Pokok dan bunga adalah hidup</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Sesuatu yang hidup mempunyai kehidupan! Ia bukan benda dan tidak mati.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Sesuatu yang hidup boleh mati.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. Sesuatu yang hidup berkehendakkan makanan untuk memberi kekuatan.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9. Sesuatu yang hidup akan membesar.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. Sesuatu yang hidup akan mempunyai anak seperti mereka sendiri.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>No.</td>
<td>Statement</td>
<td>Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------------------------------------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Seorang anak akan membesar menjadi seorang dewasa.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Biji-bijian akan tumbuh dan membesar menjadi pokok.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Sesuatu yang hidup dapat bergerak dan membesar. Jika ianya tidak dapat bergerak dan membesar, ianya bukan hidup.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Asap it bergerak. Tapi ia tidak hidup kerana ia tidak boleh membesar dan beranak.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Binatang dan pokok itu boleh bernafas.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Pokok boleh menjaga dirinya sendiri.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Binatang mempunyai cara bernafas yang berlainan.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Binatang mempunyai cara beranak yang berlainan.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Pokok berkehendakkan air, matahari dan udara untuk membuat makanannya sendiri.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Sirip ikan dapat menolong ikan untuk berenang dan memseimbangkan badannya.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Ikan boleh bernafas dalam air kerana ia ada insang.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Beberapa kelompok binatang makan kelompok binatang yang lain.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Manusia adalah binatang.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>